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ANALYSIS OF A FORTRAN PROGRAM FOR COMPUTING ELECTRIC FIELD DISTRIBUTIONS IN HETEROGENEOUS PENETRABLE NONMAGNETIC BODIES OF ARBITRARY SHAPE THROUGH APPLICATION OF TENSOR GREEN'S FUNCTIONS

John W. Penn, B.S.
David K. Cohoon, Ph.D.

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USAF SCHOOL OF AEROSPACE MEDICINE
Aerospace Medical Division (AFSC)
Brooks Air Force Base, Texas 78235

NOTICES

This preliminary report was submitted by personnel of the Biomathematics Modeling Branch, Data Sciences Division, USAF School of Aerospace Medicine, Aerospace Medical Division, AFSC, Brooks Air Force Base, Texas, under job order 7757-01-43.

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This technical report has been reviewed and is approved for publication.

John W Penn

JOHN W. PENN, B.S.
Project Scientist

Richard A. Albanese

RICHARD A. ALBANESE, M.D.
Supervisor

L J Enders

LAWRENCE J. ENDERS
Colonel, USAF, MC
Commander

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An integral equation whose solution is the electromagnetic field induced in a heterogeneous, penetrable, nonmagnetic body--e.g., a biological body--by an external source is derived and approximated by a linear equation for computer implementation. A computer program for carrying out the discrete approximation of the integral equation is described. The use of symmetry groups in saving computer storage is explained. The scattering of a plane wave by a homogeneous ball is analyzed by this program and the results are compared with those produced by a computer program that implements the Mie solution.

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PENETRABLE NONMAGNETIC BODIES OF ARBITRARY SHAPE
THROUGH APPLICATION OF TENSOR GREEN'S FUNCTIONS

PURPOSE

TGR is a Fortran IV program written for the IBM 360/65 System to compute the electric field distribution, power density distribution, and total absorbed power in a bounded, penetrable, heterogeneous, non-magnetic body subject to an incident electric field. Results are obtained through the discretization and simplification of the integral equation of electromagnetic scattering derived from Maxwell's equations by applying simplifying assumptions appropriate for the method of retarded potentials.

In the body of the text we give a terse description of the integral equation that we use. Appendix A contains the mathematical preliminaries needed to understand the complete derivation, which is given in Appendix B. The discretization of the integral equation and its representation as a matrix equation is explained in Appendix C. The reduction by the use of symmetry groups of the size of the matrix used to define the approximation of the integral equation is explained in Appendix D. Without using the latter technique the cost of running the program would be greater by from one-hundred to seven-hundred percent than it is at the present time when the scattering obstacle possesses a lesser or a greater amount of symmetry.

With this program the authors were able to observe resonance effects and predict hot spots in a biological body subjected to microwave radiation. In this preliminary report a comparison is made between results produced by the method of this report and the classical Mie solution results in the case where the impinging field is a plane wave and the scattering obstacle is a homogeneous, non-biological ball with a relative dielectric constant close to unity and a conductivity that is small. Good agreement was found between the computations produced by the two methods; the results of two numerical experiments are reported in Appendix E. The error analysis for biological bodies is being carried out, and the results will appear in a future report. The listing of the computer program along with the computer output for one of the sample problems is given in Appendix F.

MATHEMATICAL DESCRIPTION

A biological body is subjected to a time-harmonic electromagnetic wave traveling in the direction of the positive z-axis. This incident electric vector is normalized so that its amplitude is 1 volt per meter.

The incident electric vector may have the form

$$\vec{E}^i = \vec{i}\cos(k_0 z), \tag{1}$$

$$\vec{E}^i = \vec{i}\sin(k_0 z), \tag{2}$$

or

$$\vec{E}^i = \vec{i}\,(\cos(k_0 z) - i\sin(k_0 z)), \tag{3}$$

where $\vec{i}$ is a unit vector in the direction of the positive x-axis and $k_0 = \omega\sqrt{\mu_0\varepsilon_0}$ is the free space wave number.

We use the MKS (meter-kilogram-second) system of units. The magnetic field intensity H which is measured in ampere-turns per meter is given by

$$\vec{H} = (1/i\omega\mu_0)(\partial/\partial z)E_x\vec{i} , \tag{4}$$

or

$$\vec{H} = -\sqrt{(\varepsilon_0/\mu_0)}\vec{e}_2\exp(-ik_0 z). \tag{5}$$

The Poynting vector (Stratton [6 , p. 132]) is given by

$$\vec{S} = \vec{E}\times\vec{H}, \tag{6}$$

and has the units of watts per square meter. In the MKS units

$$\varepsilon_0 = 8.854\text{x}10^{-12} \text{ farads per meter,} \tag{7}$$

$$\mu_0 = 1.257\text{x}10^{-6} \text{ henrys per meter,} \tag{8}$$

and

$$\sqrt{\varepsilon_0/\mu_0} = 2.654\text{x}10^{-3} \text{ mhos}\cdot \tag{9}$$

Thus, the power density for a 1 volt per meter electric field is

$$|\vec{S}| = 2.654\text{x}10^{-3} \text{ watts per square meter .} \tag{10}$$

According to Johnson et al. [1, p. 14], power density is normally measured in milliwatts per square centimeter. If the amplitude of the incident electric field were multiplied by 61.38, then the power density would be 1 milliwatt per square centimeter.

To get the power that would be absorbed from a 1 milliwatt-per-square-centimeter beam, we simply multiply the normal output of this program by 3767., remembering that the wave impedance of free space is 376.7 ohms according to Stratton [6, p. 601] .

The authors define the tensor Green's function

$$G(r,r') = (1/(4\pi))\left[I + (1/k_0^2)\text{grad}_r\text{grad}_r\right]\left(\frac{\exp(-ik_0|r - r'|)}{|r - r'|}\right), \quad (11)$$

and show the connection between the Maxwell equations, the calculations of Van Bladel [7, p. 563] and Livesay and Chen [4, p. 1273], and obtain by neglecting surface electric current and surface magnetic charge the integral equation

$$\left[1 + \frac{\tau(r)}{3i\omega\varepsilon_0}\right]\vec{E}(r) - PV\int\tau(r')\vec{E}(r')G(r,r')dv(r') = \vec{E}^i(r), \quad (12)$$

where the PV indicates that the principal value of the integral is taken, and

$$\tau(r) = \sigma(r) + i\omega(\varepsilon(r) - \varepsilon_0). \quad (13)$$

Equation (12) is solved by subdividing the body into subregions in which the electric vector is assumed to be constant as a function of space coordinates. Thus, we assume, at least, that the diameter of a subregion does not exceed one-fourth of a wavelength. Since the velocity of light is about 30 billion centimeters per second, this means that at 1 megahertz the diameter may be only 7.5 centimeters and at 1 gigahertz the diameter may be only .0075 centimeters. Thus, without modification, it would be impossible on the present computer system to determine accurately the effect of 1 gigahertz radiation on a 180-centimeter man, because of the memory that would be needed to store information about all of the cells that would be involved in the approximation.

PROGRAM DESCRIPTION

The program is adapted from a program written by Livesay and Chen [4]. We have adopted the same input and output format adding only the capability of printing the total absorbed power. This program is faster than Chen's program and requires less storage in view of the fact that the matrix inversion routine stores and operates only on about half of the symmetric matrix defined by the discretization of (12).

Following Chen we divide space into octants. The first octant is that region of x-y-z space where x,y and z are all positive. Part or all of the scattering obstacle is assumed to occupy octant one. If it occupies any other octant it is symmetric with respect to that part that is in octant one. The use of symmetry is explained in Appendix D.

We now explain the input data. Table 1 lists the files for this input data. Table 2 is a listing of the formats for these files.

TABLE 1. INPUT DATA DESCRIPTION

	Data File	Contents
	1	N DIV
	2	COMP: Q(J), J=1,...,8; FMEG, FIELD
	3	NX, NY, NZ
	4	N
	5	$\{$AMX, AMY, AMZ, RLEPI, SIGI, DXCM$\}_1$
N cards		
		$\{$AMX, AMY, AMZ, RLEPI, SIGI, DXCM$\}_N$

Here, NDIV contains the number of subdivisions of each side of a subvolume. Next, COMP is a code name for the components of the induced electric field; it contains one of the members of the set of alpha strings denoted by {X-ONLY, XANDY., X, Y, Z.}. If an octant J is used, then the number of that octant is placed in the field for Q(J) and otherwise a blank is placed in the field; octant 1 is always used. The variable FMEG denotes the frequency in megahertz. The variable FIELD specifies the character of the input field and is an α-string belonging to the set {EXPKZ, COSKZ, SINKZ, TOTAL, EINCZ} for respectively fields of the form

EXPKZ = $\vec{i}\,\exp(-ik_o z)$, (if we use only octants 1 - 4)

COSKZ = $\vec{i}\,\cos(k_o z)$,

SINKZ = $\vec{i}\,\sin(k_o z)$,

TOTAL = $\vec{i}\,\exp(-ik_o z)$,

or

EINCZ = $\vec{i}$.

The variables NX, NY, and NZ approximate the number of cells in the X, Y, and Z directions; this information is not used. The variable N denotes the number of cells. The variables AMX, AMY, and AMZ correspond to the maximum values of X, Y, and Z coordinates of a cell in the first octant. The variables RLEPI and SIGI denote the relative dielectric constant and conductivity in mhos per meter of the cell in question. The variable DXCM is the length of the edge of the cubical cell in centimeters. The values of RLEPI and SIGI may be determined from [1] and [2].

The output is clearly labeled by the program and is self-explanatory.

The reader should be able to see how the program is used by examining the sample problem and the source listing.

TABLE 2. FORMAT STATEMENTS FOR INPUT FILES

1	FORMAT (I1)
2	FORMAT (A6,4X,8A1,2X,F1Ø·Ø,1ØX,A5)
3	FORMAT (3(I2,3X))
4	FORMAT (I3)
5	FORMAT (8F1Ø·3)

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APPENDIX A

SOME IDENTITIES IN VECTOR AND DYADIC ANALYSIS

Definition A.1. A vector in R^3 or C^3 is a triple (a_1,a_2,a_3) of real or complex numbers. We write $\vec{A} = a_1\vec{i} + a_2\vec{i} + a_3\vec{k}$ to denote that function on the set $\{\vec{i},\vec{j},\vec{k}\}$ of unit vectors along the x,y, and z axes respectively which assigns the value a_1 to $\vec{i}$, a_2 to $\vec{j}$ and a_3 to $\vec{k}$.

Definition A.2. If $\vec{A} = a_1\vec{i} + a_2\vec{j} + a_3\vec{k}$ and $\vec{B} = b_1\vec{i} + b_2\vec{j} + b_3\vec{k}$ are vectors then

$$\vec{A}\cdot\vec{B} = a_1b_1 + a_2b_2 + a_3b_3 \tag{A.1}$$

and

$$\vec{A}\times\vec{B} = (a_2b_3-a_3b_2)\vec{i} + (a_3b_1-a_1b_3)\vec{j} + (a_1b_2-a_2b_1)\vec{k}\ . \tag{A.2}$$

Definition A.3. Let ψ be a member of $C^1(R^3)$ and let $\vec{A}$ be a vector each component of which is a member of $C^1(R^3)$. Then we define

$$\text{grad}\ \psi = \nabla\psi = \frac{\partial\psi}{\partial x}\vec{i} + \frac{\partial\psi}{\partial y}\vec{j} + \frac{\partial\psi}{\partial z}\vec{k} \tag{A.3}$$

and for $\vec{A} = a_1\vec{i} + a_2\vec{j} + a_3\vec{k}$, we define $\text{curl}(\vec{A}) = \nabla\times\vec{A} =$

$$\left(\frac{\partial a_3}{\partial y} - \frac{\partial a_2}{\partial z}\right)\vec{i} + \left(\frac{\partial a_1}{\partial z} - \frac{\partial a_3}{\partial x}\right)\vec{j} + \left(\frac{\partial a_2}{\partial x} - \frac{\partial a_1}{\partial y}\right)\vec{k} \tag{A.4}$$

and

$$\operatorname{div}(\vec{A}) = \nabla \cdot \vec{A} = \frac{\partial a_1}{\partial x} + \frac{\partial a_2}{\partial y} + \frac{\partial a_3}{\partial z} . \qquad (A.5)$$

We now introduce the concept of a dyad as follows.

<u>Definition</u> A.4. <u>Suppose that the unit vectors</u> $\vec{i} = (1,0,0)$, $\vec{j} = (0,1,0)$, and $\vec{k} = (0,0,1)$ <u>are considered to be letters in an alphabet</u>. <u>Then form all the two letter</u> "<u>words</u>"

$$W = \{\vec{i}\vec{i},\vec{i}\vec{j},\vec{i}\vec{k},\vec{j}\vec{i},\vec{j}\vec{j},\vec{j}\vec{k},\vec{k}\vec{i},\vec{k}\vec{j},\vec{k}\vec{k}\} . \qquad (A.6)$$

<u>A dyad</u> G <u>can be thought of as a "three by three matrix" expressed in the form</u>

$$G = a_{(1,1)}\vec{i}\vec{i} + a_{(1,2)}\vec{i}\vec{j} + a_{(1,3)}\vec{i}\vec{k} + a_{(2,1)}\vec{j}\vec{i} + a_{(2,2)}\vec{j}\vec{j} + a_{(2,3)}\vec{j}\vec{k} + a_{(3,1)}\vec{k}\vec{i} + a_{(3,2)}\vec{k}\vec{j} + a_{(3,3)}\vec{k}\vec{k} . \qquad (A.7)$$

<u>Also, we may say that</u> G <u>is a function from the set</u> W <u>into</u> R <u>or</u> C <u>whose values on</u> $\vec{i}\vec{i},\vec{i}\vec{j},\vec{i}\vec{k},\vec{j}\vec{i},\vec{j}\vec{j},\vec{j}\vec{k}, \vec{k}\vec{i},\vec{k}\vec{j},\vec{k}\vec{k}$ <u>are respectively</u>

$$a_{(1,1)},a_{(1,2)},a_{(1,3)},a_{(2,1)},a_{(2,2)},a_{(2,3)},a_{(3,1)},a_{(3,2)},a_{(3,3)} .$$

<u>Dyads are formed naturally in several ways</u>.

<u>Definition</u> A.5. <u>If</u> $\vec{A} = a_1\vec{i} + a_2\vec{j} + a_3\vec{k}$ <u>and</u> $\vec{B} = b_1\vec{i} + b_2\vec{j} + b_3\vec{k}$ <u>are vectors, then</u> $\vec{A}\vec{B} = a_1b_1\vec{i}\vec{i} + a_1b_2\vec{i}\vec{j} + a_1b_3\vec{i}\vec{k} + a_2b_1\vec{j}\vec{i} + a_2b_2\vec{j}\vec{j} +$

$$+ a_2b_3\vec{i}\vec{k} + a_3b_1\vec{k}\vec{i} + a_3b_2\vec{k}\vec{j} + a_3b_3\vec{k}\vec{k} . \qquad (A.8)$$

Definition A.6. If b_1, b_2, and b_3 are functions in $C^1(R^3)$, then $\vec{B} = b_1\vec{i} + b_2\vec{j} + b_3\vec{k}$ implies that $\text{grad}(\vec{B}) = \nabla\vec{B} =$

$$\frac{\partial b_1}{\partial x}\vec{i}\vec{i} + \frac{\partial b_2}{\partial x}\vec{i}\vec{j} + \frac{\partial b_3}{\partial x}\vec{i}\vec{k}$$

$$+ \frac{\partial b_1}{\partial y}\vec{j}\vec{i} + \frac{\partial b_2}{\partial y}\vec{j}\vec{j} + \frac{\partial b_3}{\partial y}\vec{j}\vec{k}$$

$$+ \frac{\partial b_1}{\partial z}\vec{k}\vec{i} + \frac{\partial b_2}{\partial z}\vec{k}\vec{j} + \frac{\partial b_3}{\partial z}\vec{k}\vec{k} \quad . \tag{A.9}$$

Whereas we used (A.5) and the divergence operation to obtain a scalar valued function from a vector valued function, we also use the divergence to obtain a vector valued function from a dyadic valued function as follows.

Definition A.7. Let $G = a_{(1,1)}\vec{i}\vec{i} + a_{(1,2)}\vec{i}\vec{j} + a_{(1,3)}\vec{i}\vec{k} + a_{(2,1)}\vec{j}\vec{i}$

$$+ a_{(2,2)}\vec{j}\vec{j} + a_{(2,3)}\vec{j}\vec{k} + a_{(3,1)}\vec{k}\vec{i} + a_{(3,2)}\vec{k}\vec{j}$$

$$+ a_{(3,3)}\vec{k}\vec{k} \tag{A.10}$$

and define

$$\text{div}(G) = \nabla\cdot G = [(\partial/\partial x)a_{(1,1)} + (\partial/\partial y)a_{(2,1)} + (\partial/\partial z)a_{(3,1)}]\vec{i} +$$

$$[(\partial/\partial x)a_{(1,2)} + (\partial/\partial y)a_{(2,2)} + (\partial/\partial z)a_{(3,2)}]\vec{j} + [(\partial/\partial x)a_{(3,1)} +$$

$$(\partial/\partial y)a_{(3,2)} + (\partial/\partial z)a_{(3,3)}]\vec{k} \; . \tag{A.11}$$

Now we may make the following generalization of the Gauss divergence theorem which we will use later on.

Theorem A.1. Let G be a differentiable dyadic function on a neighborhood of the region V of R^3 with boundary ∂V.
Let $\vec{n}$ denote the normal vector to the surface ∂V bounding V.
Then

$$\int_{\partial V} \vec{n} \cdot G \, da = \int_{V} \mathrm{div}(G) \, dv , \tag{A.12}$$

where da is the surface area and dv is the volume differential of ∂V and V respectively.

Proof of Theorem A.1. The proof follows by using (A.11) and the usual Gauss divergence theorem component by component.

For the sake of completeness we list the following identities for vector valued functions,which we also use later in the paper.

Proposition A.1. For all differentiable vector valued functions P and Q we have

$$\mathrm{div}(\vec{P} \times \vec{Q}) = \vec{Q} \cdot \mathrm{curl}(\vec{P}) - \vec{P} \cdot \mathrm{curl}(\vec{Q}) \tag{A.13}$$

and

$$\mathrm{curl}(\mathrm{curl}(\vec{P})) = \mathrm{grad}(\mathrm{div}(\vec{P})) - \Delta\vec{P} , \tag{A.14}$$

where the Laplacian Δ acts on each component of $\vec{P}$ by the rule,

$$\Delta\psi = \frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2} \tag{A.15}$$

for all scalar functions ψ. Also $\vec{P} = b_1\vec{i} + b_2\vec{j} + b_3\vec{k}$ implies

$$\mathrm{grad}(\vec{P}) = \nabla\vec{P} = (\nabla b_1)\vec{i} + (\nabla b_2)\vec{j} + (\nabla b_3)\vec{k}\ , \tag{A.16}$$

$$\mathrm{div}(\vec{P}\times \mathrm{curl}(\vec{Q})) = \mathrm{curl}(\vec{P})\cdot\mathrm{curl}(\vec{Q}) - \vec{P}\cdot\mathrm{curl}(\mathrm{curl}(\vec{Q})), \tag{A.17}$$

$$\mathrm{div}(\vec{P}\times \mathrm{curl}(\vec{Q}) - \vec{Q}\times \mathrm{curl}(\vec{P})) = \vec{Q}\cdot\mathrm{curl}(\mathrm{curl}(\vec{P})) - \vec{P}\cdot\mathrm{curl}(\mathrm{curl}(\vec{Q})) \tag{A.18}$$

and

$$\mathrm{curl}(P\times Q) = \vec{P}\,\mathrm{div}(\vec{Q}) - \vec{Q}\mathrm{div}(\vec{P}) + (\vec{Q}\cdot\nabla)\vec{P} - (\vec{P}\cdot\nabla)\vec{Q} \tag{A.19}$$

where for any vector functions $\vec{A}$ and $\vec{B}$ we define

$$(\vec{A}\cdot\nabla)\vec{B} = Lb_1\vec{i} + Lb_2\vec{j} + Lb_3\vec{k} \tag{A.20}$$

where the operator L is defined by the rule

$$L\psi = a_1(\partial/\partial x)\psi + a_2(\partial/\partial y)\psi + a_3(\partial/\partial z)\psi$$

for any scalar functions ψ.

We also need the following.

Proposition A.2. Let ϕ be a scalar function and $\vec{A}$ a vector function. Then

$$\vec{Q} = \phi\vec{A}$$

implies

$$\nabla\times\vec{Q} = \nabla\phi \times \vec{A} \,. \tag{A.21}$$

We make use of this result and the following immediate consequence of the Gauss divergence theorem to derive the basic integral equation of electromagnetic scattering.

Proposition A.3. *Let* V *be a region with a boundary surface* ∂V *whose normal is* $\vec{n}$. *Then for all smooth vector valued functions* $\vec{P}$ *and* $\vec{Q}$ *we have the relation*

$$\int_{\partial V} (\vec{P}\times(\nabla\times\vec{Q}) - \vec{Q}\times(\nabla\times\vec{P}))\cdot\vec{n}\, da = \int_V (\vec{Q}\cdot\nabla\times\nabla\times\vec{P} - \vec{P}\cdot\nabla\times\nabla\times\vec{Q})dv \,. \tag{A.22}$$

Remark. The reader may find it interesting to extend the definitions A.2 and A.3 to functions defined on the n-letter words formed from the "letters" $\vec{i}, \vec{j}$, and $\vec{k}$. These generalizations will be the subject of a future report.

APPENDIX B

DERIVATION OF THE FIELD EQUATIONS OF ELECTROMAGNETIC SCATTERING

We use Maxwell's equations in the form

$$\nabla \times \vec{E} + \frac{\partial \vec{B}}{\partial t} = -\vec{J}^* , \tag{B.1}$$

$$\nabla \times \vec{H} - \frac{\partial \vec{D}}{\partial t} = \vec{J} , \tag{B.2}$$

$$\nabla \cdot \vec{B} = \rho^* , \tag{B.3}$$

and

$$\nabla \cdot \vec{D} = \rho . \tag{B.4}$$

The constitutive relations have the form,

$$\vec{B} = \mu \vec{H} \tag{B.5}$$

and

$$\vec{D} = \varepsilon \vec{E} . \tag{B.6}$$

The sources are $\vec{J}^*$, magnetic current density, $\vec{J}$, electrical current density, ρ^*, magnetic charge density, and ρ, electrical charge density. According to Stratton [6, page 229], the magnetic moment of a magnetized piece of matter is

$$\vec{m} = \int_V \vec{r}\, \rho^*(\xi,\eta,\zeta)dv + \int_{\partial V} \vec{r}\, \omega^*(\xi,\eta,\zeta)da \tag{B.7}$$

where ω^* is a surface density and $\vec{r}$ is the position vector of points in V or ∂V . We define the magnetization vector $\vec{M}$ by the relation

$$\vec{M} = \int_V \vec{m}\, dv . \tag{B.8}$$

Let us assume $\vec{J}^* = 0$ and $\rho^* = 0$. Also assume that $\vec{B}$ and $\vec{E}$ are time harmonic, which means that

$$\vec{B} = \vec{B}(x,y,z)\exp(-i\omega t), \tag{B.9}$$

and

$$\vec{E} = \vec{E}(x,y,z)\exp(-i\omega t). \tag{B.10}$$

Then (B.1) -(B.6) and (B.9) -(B.10)

imply that

$$\nabla \times \vec{E} - i\omega\mu\vec{H} = 0, \tag{B.11}$$

$$\nabla \times \vec{H} + i\omega\varepsilon\vec{E} = \vec{J}, \tag{B.12}$$

$$\nabla \cdot \vec{H} = 0, \tag{B.13}$$

and

$$\nabla \cdot \vec{E} = \rho/\varepsilon. \tag{B.14}$$

The continuity equation implies that

$$\nabla \cdot \vec{J} - i\omega\rho = 0. \tag{B.15}$$

From (B.11) and (B.12) we deduce that

$$\nabla \times \nabla \times \vec{E} = \omega^2\mu\varepsilon\vec{E} + i\omega\mu\vec{J}. \tag{B.16}$$

If we define

$$k^2 = \omega^2\mu\varepsilon, \tag{B.17}$$

we deduce from (B.16) and the definition

$$\vec{P} = \vec{E}, \tag{B.18}$$

that

$$\nabla \times \nabla \times \vec{P} = k^2\vec{E} + i\omega\mu\vec{J}.$$

We define

$$\phi = \exp(ikr)/r \tag{B.19}$$

and

$$\vec{Q} = \phi \vec{A}, \tag{B.20}$$

where

$$\vec{A} = A_1\vec{i} + A_2\vec{j} + A_3\vec{k}$$

is a unit vector in an arbitrary direction.

A calculation shows that

$$\Delta\phi + k^2\phi = 0, \tag{B.21}$$

and

$$\nabla\times\nabla\times\vec{Q} = k^2\vec{A}\,\phi + (\vec{A}\cdot\nabla)\,\nabla\phi \quad . \tag{B.22}$$

Let us observe that

$$(\vec{A}\cdot\nabla)\,\vec{\nabla}\phi = A_1\frac{\partial}{\partial x}(\vec{\nabla}\phi) + A_2\left(\frac{\partial}{\partial y}\,\vec{\nabla}\phi\right) + A_3\left(\frac{\partial}{\partial z}\,\vec{\nabla}\phi\right)$$

$$= \vec{i}\left[A_1\frac{\partial^2\phi}{\partial x} + A_2\frac{\partial^2\phi}{\partial x\partial y} + A_3\frac{\partial^2\phi}{\partial x\partial z}\right]$$

$$+ \vec{j}\left[A_1\frac{\partial^2\phi}{\partial x\partial y} + A_2\frac{\partial^2\phi}{\partial y^2} + A_3\frac{\partial^2\phi}{\partial y\partial z}\right]$$

$$+ \vec{k}\left[A_1\frac{\partial^2\phi}{\partial x\partial z} + A_2\frac{\partial^2\phi}{\partial y\partial z} + A_3\frac{\partial^2}{\partial z^2}\right]$$

$$= \text{grad}\,\left(A_1\frac{\partial}{\partial x} + A_2\frac{\partial\phi}{\partial y} + A_3\frac{\partial\phi}{\partial z}\right)$$

$$= \nabla(\vec{A}\cdot\vec{\nabla}\phi\,). \tag{B.23}$$

Therefore, we conclude that

$$\nabla\times\nabla\times\vec{Q} = \vec{A}k^2\phi + \nabla(\vec{A}\cdot\vec{\nabla}\phi) \quad . \tag{B.24}$$

Also,

$$\nabla\times\nabla\times\vec{P} = k^2\vec{E} + i\omega\mu\vec{J}\,\cdot \tag{B.25}$$

Thus, from proposition A-3 we see that

$$\int_V (\vec{Q}\cdot\nabla\times\nabla\times\vec{P} - \vec{P}\cdot\nabla\times\nabla\times\vec{Q})dv =$$

$$\int\{\phi \vec{A}\cdot(k^2\vec{E} + i\omega\mu \vec{J}) - \vec{E}\cdot(k^2\vec{A}\phi + \vec{\nabla}(\vec{A}\cdot\vec{\nabla}\phi)\}dv$$

$$= \int_S\left[\vec{E}\times(\vec{\nabla}\phi\times\vec{A}) - \phi\vec{A}\times(\nabla\times\vec{E})\right]\cdot\vec{n}\, da$$

$$= \int_S\left[(\vec{n}\times\vec{E})\cdot(\nabla\phi\times\vec{A}) - i\omega\mu(\phi\vec{A}\times\vec{H})\cdot\vec{n}\right]da$$

$$= \int_S\left[(\vec{n}\times\vec{E})\times\vec{\nabla}\phi\right]\cdot\vec{A} - i\omega\mu(\nabla\vec{\phi}\times\vec{A})\cdot(\vec{H}\times\vec{n})da$$

$$= \int_S\left[(\vec{n}\times\vec{E})\times\vec{\nabla\phi} + i\omega\mu\phi(\vec{n}\times\vec{H})\right]\cdot\vec{A}\, da \qquad (B.26)$$

Simplifying (B.26) we find that

$$\int_V(\vec{Q}.\nabla\times\nabla\times\vec{P} - \vec{P}\cdot\nabla\times\nabla\times\vec{Q})dv$$

$$= \vec{A}\cdot\int_V i\omega\mu\vec{J}\phi\, dv - \int_V\vec{E}\cdot\nabla(\vec{A}\cdot\nabla\phi)\,dv$$

$$= \vec{A}\cdot\left[\int_S\{(\vec{n}\times\vec{E})\times\vec{\nabla}\phi + i\omega\mu\phi(\vec{n}\times\vec{H})\}\, da\right] \qquad (B.27)$$

Now we make use of the fact that

$$\int_S(\vec{E}(\vec{\nabla\phi}\cdot\vec{A}))\cdot\vec{n}\, da = \int_V \mathrm{div}(\vec{E}(\vec{\nabla\phi}\cdot\vec{A}))dv$$

$$= \int_V\left[\vec{E}\cdot\nabla(\vec{\nabla\phi}\cdot\vec{A}) + (\vec{\nabla\phi}\cdot\vec{A})(\nabla\cdot\vec{E})\right]dv \quad . \qquad (B.28)$$

Thus,

$$\int_V \vec{E}\cdot\nabla(\vec{\nabla\phi}\cdot\vec{A}) = -\vec{A}\cdot\left[\int_V(\nabla\cdot\vec{E})\vec{\nabla\phi}dv - \int_S(\vec{E}\cdot n)\,\vec{\nabla\phi}\, da\right] \qquad (B.29)$$

Substituting (B.29) into (B.27), we deduce that

$$\vec{A}\cdot\left[\int_V \{i\omega\mu\vec{J}\phi + (\nabla\cdot\vec{E})\vec{\nabla\phi}\}dv - \int_S (\vec{E}\cdot\vec{n})\vec{\nabla\phi}\,da\right]$$

$$= \vec{A}\cdot\left[\int_S \{(n\times\vec{E})\times\vec{\nabla\phi} + i\omega\mu(\vec{n}\times\vec{H})\phi\}da\right] . \tag{B.30}$$

Therefore, since $\vec{A}$ is arbitrary

$$\int_V \{i\omega\mu\vec{J}\phi + (\nabla\cdot E)\ \vec{\nabla\phi}\}\,dv =$$

$$\int_S \{(\vec{E}\cdot\vec{n})\ \vec{\nabla\phi} + (\vec{n}\times\vec{E})\times\ \vec{\nabla\phi} + i\omega\mu(\vec{n}\times\vec{H})\,\phi\}da . \tag{B.31}$$

Let S consist of the boundary of V together with a sphere, ∂B, of radius r_1 circumscribed about the point (x^1,y^1,z^1) whose normal is directed out of V towards the center of the ball B of radius r_1. We must compute the contribution of the right side of (B.31) to the integral over the sphere. We have

$$\vec{\nabla\phi} = [\frac{ik\exp(ikr)}{r} - \frac{\exp(ikr)}{r^2}]\vec{e}_r , \tag{B.32}$$

where $\vec{e}_r$ is a vector from the center of B outward. Since

$$\lim_{r_1\to 0} \int_0^{2\pi}\int_0^{\pi} i\omega\,\mu(\vec{n}\times\vec{H})\,\frac{\exp(ikr_1)}{r_1}\,r_1^2\,\sin\phi\,d\phi\,d\theta, = 0 , \tag{B.33}$$

we observe that

$$\lim_{r_1\to 0} \int_{\partial B} \{i\omega\,\mu(\vec{n}\times\vec{H})\phi + (\vec{n}\times\vec{E})\times\vec{\nabla\phi} + (\vec{n}\cdot\vec{E})\ \vec{\nabla\phi}\}da$$

$$= \lim_{r_1\to 0} \int_{\partial B} \{(\vec{n}\times\vec{E})\times\vec{\nabla\phi} + (\vec{n}\cdot\vec{E})\ \vec{\nabla\phi}\}da.$$

Thus,

$$\int \{ i\omega\mu \vec{J}\phi + (\rho/\varepsilon)\vec{\nabla}\phi \} dv =$$

$$\lim_{r_1 \to 0} \int_{\partial B} \psi(r_1) \left[(\vec{n} \times \vec{E}) \times \vec{n} + (\vec{n} \cdot \vec{E})\vec{n} \right] da , \tag{B.34}$$

where we have used the fact that

$$\vec{e}_r = -\vec{n} \tag{B.35}$$

and

$$\psi(r_1) = \left(\frac{1}{r_1} - ik \right) \phi\ (r_1) \ . \tag{B.36}$$

We now prove the following Lemma.

<u>Lemma</u> B.1. <u>If</u> $\vec{n} = A\vec{i} + B\vec{j} + C\vec{k}$, <u>then</u> $(\vec{n} \times \vec{E}) \times \vec{n} + (\vec{n} \cdot \vec{E})\vec{n} =$ $(A^2 + B^2 + C^2)\ \vec{E}$. (B.37)

<u>Proof of Lemma</u> B.1.

Observe that

$$\vec{n} \times \vec{E} = \begin{vmatrix} i & j & k \\ A & B & C \\ E_x & E_y & E_z \end{vmatrix}$$

$$= \vec{i}(BE_z - CE_y) - \vec{j}(AE_z - CE_x) + \vec{k}(AE_y - BE_x)$$

$$= \vec{i}(BE_z - CE_y) + \vec{j}(CE_x - AE_z) + \vec{k}(AE_y - BE_x) \ . \tag{B.38}$$

Also,

$$(\vec{n} \times \vec{E}) \times \vec{n} =$$

$$\begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ BE_z - CE_y & CE_x - AE_z & AE_y - BE_x \\ A & B & C \end{vmatrix} .$$

Thus,

$$(\vec{n}\times\vec{E})\times\vec{n} =$$

$$(C^2E_x - ACE_z - ABE_y + B^2E_x)\vec{i}$$

$$+ [(A^2+C^2)E_y - BAE_x - BCE_z]\vec{j}$$

$$+ [(B^2+A^2)E_z - CBE_y - ACE_x]\vec{k} \quad . \tag{B.39}$$

We conclude that

$$(\vec{n}\times\vec{E})\times\vec{n} + (\vec{n}\cdot\vec{E})\vec{n} = \{[(B^2+C^2)E_x - A(BE_y+CE_z)]\vec{i}$$

$$+ [(A^2+C^2)E_y - B(AE_x+CE_z)]\vec{j}$$

$$+ [(A^2+B^2)E_z - C(AE_x+ BE_y)]\vec{k}\} + [A(AE_x+BE_y+CE_z)]\vec{i}$$

$$+ B(AE_x+BE_y+CE_z)\vec{j}$$

$$+ C(AE_x + BE_y + CE_z)\vec{k}$$

$$= (A^2+B^2+C^2)\{E_x\vec{i} + E_y\vec{j} + E_z\vec{k}\} . \tag{B.40}$$

This completes the proof of Lemma B.1.

<u>Lemma</u> B.2. <u>If</u> $\phi(r) = \exp(ikr)/r$,

<u>then</u>

$$\lim_{r_1\to 0} \int_{\partial B} \{i\omega\mu(\vec{n}\times\vec{H})\phi + (\vec{n}\times\vec{E})\times\vec{\nabla}\phi + (\vec{n}\cdot\vec{E})\vec{\nabla}\phi\}da$$

$$= 4\pi\vec{E}(x^1,y^1,z^1) , \tag{B.41}$$

<u>where</u>

$$r_1 = \sqrt{(x-x^1)^2 + (y-y^1)^2 + (z-z^1)^2} \tag{B.42}$$

<u>and where</u> B <u>is the ball of radius</u> r_1 <u>centered at</u> (x^1,y^1,z^1).

<u>Proof of Lemma</u> B.2. If $\vec{n} = -\vec{e}_r = -\vec{\nabla}\phi/\|\vec{\nabla}\phi\|$, then applying Lemma B.1 and (B.33) - (B.36), we observe that

$$\lim_{r_1\to 0} \int_{\partial B} \{i\omega\mu(\vec{n}\times\vec{H})\phi + (\vec{n}\times\vec{E})\times\nabla\phi + (\vec{n}\cdot\vec{E})\nabla\phi\}da$$

$$= \lim_{r_1\to 0} \int_{\partial B} \psi(r_1)\,\vec{E}(x,y,z)da$$

$$= \lim_{r_1\to 0} \int_0^{2\pi}\int_0^{\pi} \left[\frac{ik\exp(ikr_1)}{r_1} - \frac{\exp(ikr_1)}{r_1^2}\right]\vec{E}(x,y,z)r_1^2\sin\phi d\phi d\theta$$

$$= \vec{E}(x',y',z')\int_0^{2\pi}\int_0^{\pi}\sin(\phi)d\phi d\theta = 4\pi\vec{E}(x',y',z'). \quad (B.43)$$

<u>Theorem</u> B.1. <u>In a nonmagnetic media with</u> $\vec{J}^* = 0$ <u>we observe that</u>

$$\vec{E}(x', y', z') = \frac{1}{4\pi}\int_V (i\omega\mu\vec{J}\phi + (\nabla\cdot E)\nabla\phi)dv$$

$$- \frac{1}{4\pi}\int_S \left[i\omega\mu(\vec{n}\times\vec{H})\phi + (\vec{n}\times\vec{E})\times\nabla\phi + (\vec{n}\cdot\vec{E})\nabla\phi\right]da \quad . \quad (B.44)$$

<u>Proof</u>. This follows from the basic relation (B.26) and Lemmas B.1 and B.2. where $\vec{P} = \vec{E}$ and $\vec{Q} = \phi\vec{A}$.

A material nonmagnetic body can be conceived as a region of free space filled with charges with density ρ, a current with flux density $\vec{J}$, and bounded by a surface with a charge density η. If we assume time-harmonic fields,then the continuity equation implies that

$$\operatorname{div}(\vec{J}) + i\omega\rho = 0 \quad (B.45)$$

which implies that

$$\rho = \left(\frac{-1}{i\omega}\right)\operatorname{div}(\vec{J}) = \frac{i}{\omega}\operatorname{div}(\vec{J}) \; . \quad (B.46)$$

Now we wish to define surface chnrge density η. In figure B.1 $\vec{J}$- denotes the current density inside the surface and $\vec{J}$+ denotes the current density immediately outside the surface.

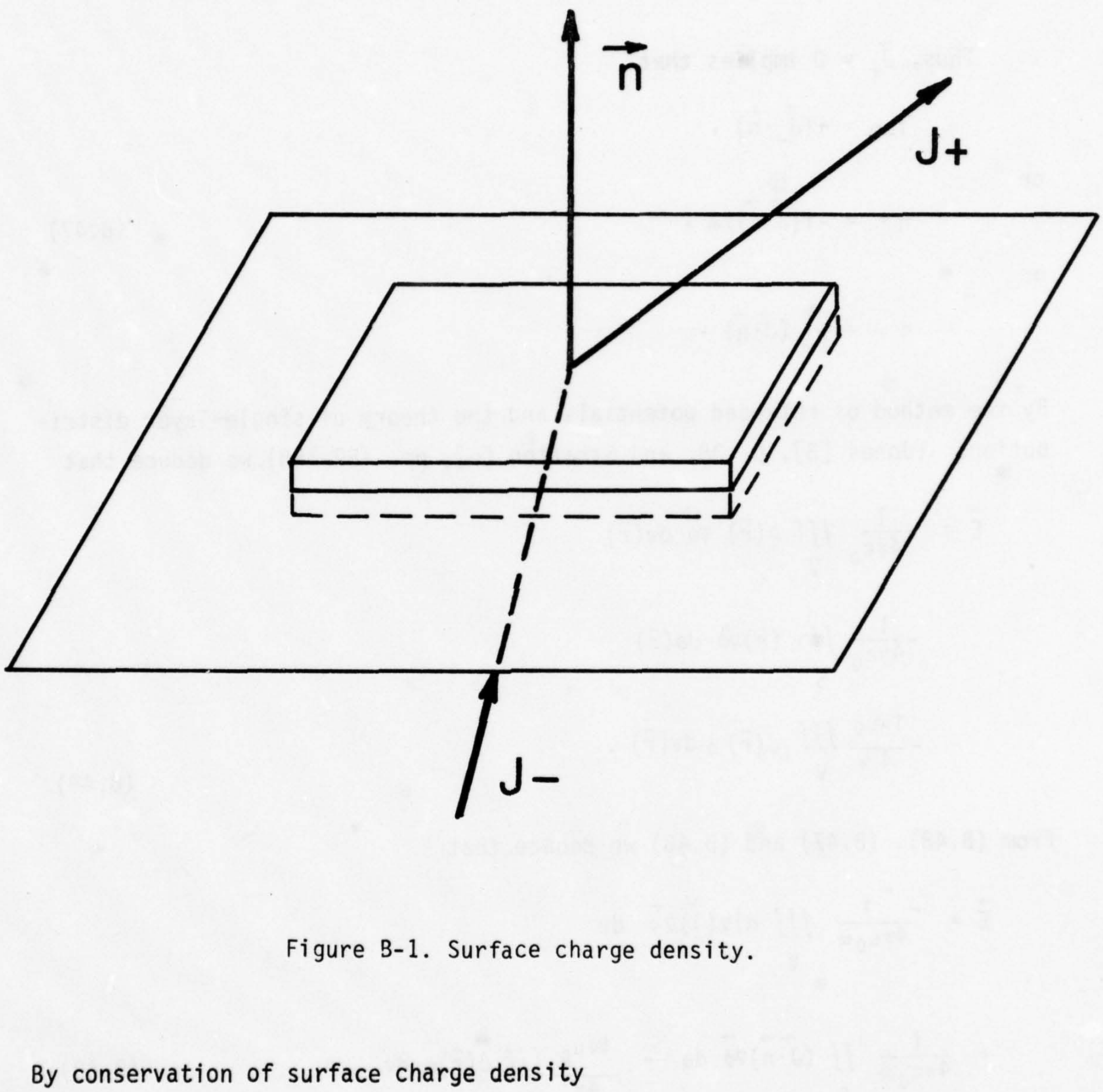

Figure B-1. Surface charge density.

By conservation of surface charge density

$$\eta(t+\Delta t)A - \eta(t)\,A + [\,(\vec{J}_+ \cdot \vec{n})\,A - (\vec{J}_- \cdot \vec{n}\,)A]\Delta t = 0\,.$$

Thus, $\vec{J}_+ = 0$ implies that

$$i\omega\eta = +(\vec{J}_-\cdot\vec{n}) ,$$

or

$$\eta = -i(\vec{J}\cdot\vec{n})/\omega , \tag{B.47}$$

or

$$\eta = \frac{1}{i\omega}(\vec{J}\cdot\vec{n}) .$$

By the method of retarded potentials and the theory of single-layer distributions (Jones [3], p. 38, and Stratton [6], pp. 187-188), we deduce that

$$\begin{aligned}\vec{E} = &-\frac{1}{4\pi\varepsilon_0}\iiint_V \rho(\bar{r})\,\vec{\nabla}\phi\,dv(\bar{r})\\ &-\frac{1}{4\pi\varepsilon_0}\iint_S \eta(\bar{r})\vec{\nabla}\phi\,da(\bar{r})\\ &-\frac{i\omega\mu_0}{4\pi}\iiint_V \vec{J}(\bar{r})\,\phi\,dv(\bar{r}) .\end{aligned} \tag{B.48}$$

From (B.48), (B.47) and (B.46) we deduce that

$$\begin{aligned}\vec{E} = &-\frac{i}{4\pi\varepsilon_0\omega}\iiint_V \mathrm{div}(\vec{J})\vec{\nabla}\phi\,dv\\ &+\frac{i}{4\pi\varepsilon_0\omega}\iint_S (\vec{J}\cdot\vec{n})\vec{\nabla}\phi\,da - \frac{i\omega\mu_0}{4\pi}\iiint_V \vec{J}(\bar{r})\phi\,dv .\end{aligned} \tag{B.49}$$

By dyadic analysis for all vectors $\vec{A}$ and $\vec{B}$, we have

$$\mathrm{div}(\vec{A}\vec{B}) = \mathrm{div}(\vec{A})\vec{B} + \vec{A} \cdot (\mathrm{grad}\ \vec{B}) \cdot \tag{B.50}$$

Thus,

$$\iiint_V \mathrm{div}(\vec{A}\vec{B})dv = \iint_S (\vec{n}\cdot\vec{A})\vec{B}\ dS$$

$$= \iiint_V \left[\mathrm{div}(\vec{A})\vec{B} + \vec{A}\cdot\mathrm{grad}\ \vec{B}\right] dv \ . \tag{B.51}$$

Letting

$$\vec{A} = \vec{J} \tag{B.52}$$

and

$$\vec{B} = \mathrm{grad}\,\phi \tag{B.53}$$

in (B.51), we deduce that

$$\frac{1}{i\omega 4\pi\varepsilon_0} \iiint_V \mathrm{div}(\vec{J})\mathrm{grad}_r\phi dv =$$

$$\frac{1}{i\omega 4\pi\varepsilon_0}\left[\iint_{S+\Sigma} (\vec{n}\cdot\vec{J})\mathrm{grad}_r\,\phi\ da - \iiint_V \vec{J}\cdot\mathrm{grad}_r\mathrm{grad}_r\phi dv\right] \cdot \tag{B.54}$$

Substituting (B.54) into (B.49) we deduce that

$$\vec{E} = \frac{1}{4\pi\varepsilon_0 i\omega}\left[\iint_{S+\Sigma} (\vec{n}\cdot\vec{J})\mathrm{grad}_r\phi da - \iiint_V \vec{J}\cdot\mathrm{grad}_r\mathrm{grad}_r\phi dv\right]$$

$$- \frac{1}{4\pi\varepsilon_0 i\omega}\iint_S (\vec{n}\cdot\vec{J})\mathrm{grad}_r\phi da - \frac{i\omega\mu_0}{4\pi}\iiint_V \vec{J}(\bar{r})\phi dv(\bar{r}) \tag{B.55}$$

which implies that

$$\vec{E} = -\frac{1}{4\pi\varepsilon_0 i\omega} \iiint_V \vec{J}\cdot\text{grad}_r\,\text{grad}_r\phi\,dv$$

$$-\frac{i\omega\mu_0}{4\pi} \iiint_V \vec{J}(\bar{r})\,\phi\,dv(\bar{r})$$

$$+\frac{1}{4\pi\varepsilon_0 i\omega} \iint_{\Sigma_\rho} (\vec{n}\cdot\vec{J})\,\text{grad}_r\,\phi\,da, \tag{B.56}$$

where Σ_ρ is a spherical surface of radius ρ surrounding the observation point.

<u>Lemma</u> B.3. <u>If</u> $\phi(r,\bar{r})$ <u>is defined by</u>

$$\phi(r,\bar{r}) = \frac{\exp(-ik_0|r-\bar{r}|)}{|r-\bar{r}|}, \tag{B.57}$$

<u>then</u>

$$\lim_{\rho\to 0} \int_{\Sigma_\rho} (\vec{n}\cdot\vec{J})\,\text{grad}_r\phi\,da = -\frac{4\pi}{3}\vec{J}(r) . \tag{B.58}$$

<u>Proof of Lemma</u> B.3. Observe that $\lim\limits_{\rho\to 0} \int_{\Sigma_\rho} (\vec{n}\cdot\vec{J})\,\text{grad}_r\phi\,da =$

$$-\lim_{\rho\to 0} \int_{\Sigma_\rho} (\sin\phi\cos\theta\, A + \sin\phi\sin\theta B + \cos\phi C)\,\text{grad}\,\phi\,da, \tag{B.59}$$

where $\vec{J} = A\vec{i} + B\vec{j} + C\vec{k}$ and

$$\text{grad}\,\phi = \frac{1}{\rho^2}(\vec{i}\sin\phi\cos\theta + \vec{j}\sin\phi\sin\theta + \vec{k}\cos\theta)$$

$$+ F(\rho,\phi,\theta)/\rho , \tag{B.60}$$

where $F(\rho,\phi,\theta)$ is a bounded function.

Thus, substituting (B.60) into (B.59), we find that

$$\lim_{\rho\to 0} \int_{\Sigma_\rho} (\vec{n}\cdot\vec{J})\,\text{grad}_r\,\phi\, da =$$

$$- \Bigg[\vec{i} \int_0^{2\pi}\!\!\int_0^{\pi} (\sin\phi\cos\theta A + \sin\phi\sin\theta B + \cos\phi C)(\sin\phi\cos\theta)\sin\phi\, d\phi\, d\theta$$

$$+ \vec{j} \int_0^{2\pi}\!\!\int_0^{\pi} (\sin\phi\cos\theta A + \sin\phi\sin\theta B + \cos\phi C)(\sin\phi\sin\theta)\sin\phi\, d\phi\, d\theta$$

$$+ \vec{k} \int_0^{2\pi}\!\!\int_0^{\pi} (\sin\phi\cos\theta A + \sin\phi\sin\theta B + \cos\phi C)\cos\phi\sin\phi\, d\phi\, d\theta \Bigg]. \tag{B.61}$$

To evaluate the right side of (B.61) we must evaluate three simple integrals.

These are

$$I_1 = \int_0^{2\pi}\!\!\int_0^{\pi} \sin^3\phi\cos^2\theta\, d\phi\, d\theta\ , \tag{B.62}$$

$$I_2 = \int_0^{2\pi}\!\!\int_0^{\pi} \sin^3\phi\sin^2\theta\, d\phi\, d\theta\ , \tag{B.63}$$

and

$$I_3 = \int_0^{2\pi}\!\!\int_0^{\pi} \sin\phi\cos^2\phi\, d\phi\, d\theta\ . \tag{B.64}$$

Observe that $I_2 = I_3$ and that

$$I_3 = 2\pi\left(\frac{-\cos^3\phi}{3}\right)\Bigg|_0^{\pi} = 4\pi/3\ . \tag{B.65}$$

Hence,

$$I_1 = \left[-\int_{\phi=0}^{\phi=\pi} (1-\cos^2\phi)\, d\cos\phi \right] \left[\int_0^{2\pi} \left[\frac{1+\cos(2\theta)}{2}\right] d\theta \right]$$

$$= -\left(\cos\phi - \frac{\cos^3\phi}{3}\right)\Bigg|_0^{\pi} \cdot \pi = 4\pi/3\ . \tag{B.66}$$

Thus, we deduce that

$$\lim_{\rho\to 0} \int_{\Sigma_\rho} (\vec{n}\cdot\vec{J})\,\mathrm{grad}_r\,\phi\,da \;=\; -(4\pi/3)(A\vec{i} + B\vec{j} + C\vec{k}) \tag{B.67}$$

when $\vec{J}$ is a constant vector. Since $\vec{J}(\bar{r})$ is continuous, this proves (B.58).

Substituting (B.58) into (B.56) we obtain the following result.

<u>Theorem</u> B.2 <u>If</u> $\vec{J}$ <u>is the current density in a region,</u> V<u>, of free space, then,</u>

$$\vec{E}(r) = -\frac{1}{4\pi\varepsilon_0 i\omega}\iiint_V \vec{J}\cdot\mathrm{grad}_{r'}\mathrm{grad}_r\,\phi\,dv$$

$$-\frac{i\omega\mu_0}{4\pi}\iiint_V \vec{J}(r)\,\phi\,dv - \frac{1}{3\varepsilon_0 i\omega}\vec{J}(r) \tag{B.68}$$

<u>at every point</u> r <u>in</u> V.

We now introduce the Green's function dyadic.

<u>Definition</u> B.1. <u>For every pair of points</u> r <u>and</u> $\bar{r}$ <u>we define</u>

$$G(r,\bar{r}) = -\frac{1}{4\pi}\left(I + \frac{1}{k_0^2}\,\mathrm{grad}_r\mathrm{grad}_r\right)\frac{\exp(-ik_0|r-\bar{r}|)}{|r-\bar{r}|} \tag{B.69}$$

<u>where</u> $k_0^2 = \omega^2\mu_0\varepsilon_0$ <u>and where</u> I <u>is the identity dyadic</u>.

<u>Theorem</u> B.3 <u>If</u> $\vec{J}$ <u>is the current density in a region</u>, V, <u>of free space</u>, <u>then</u>

$$\vec{E}(r) + \frac{\vec{J}(r)}{3i\omega\varepsilon_0} = i\omega\mu_0\left(PV\left(\int_V \vec{J}(\bar{r})\cdot G(r,\bar{r})\,dv\right)\right) \tag{B.70}$$

<u>where the right side of (B.70) is a principal value integral</u>.

<u>Proof</u>. Observe that

$$-\frac{i\omega\mu_0}{4\pi k_0^2} = -\frac{i\omega\mu_0}{4\pi\omega^2\mu_0\varepsilon_0} = \frac{1}{4\pi i\omega\varepsilon_0}$$

and that

$$\mathrm{grad}_{r'}\,\mathrm{grad}_r\,\phi = -\mathrm{grad}_r\mathrm{grad}_r\,\phi\ .$$

Thus, (B.70) follows from Definition B.1 and (B.68).

Define $G_{(x_p,x_q)}(r,r')$ to be the (p,q)-entry of the Green's matrix. We have

$$G_{(x_p,x_q)}(r,r') = -i\omega\mu_0\left[S_{(p,q)} + \frac{1}{k_0^2}\,\frac{\partial^2}{\partial x_p\partial x_q}\phi(r,r')\right] \tag{B.71}$$

Observe that if we define

$$\psi(\rho) = \phi(r,r') = \frac{\exp(-ik_0|r-r'|)}{|r-r'|}, \tag{B.72}$$

and

$$\rho = |r-r'|, \tag{B.73}$$

then

$$\frac{\partial\phi}{\partial x_p} = \psi'(\rho)\,\frac{(x_p - x_p')}{\rho} \tag{B.74}$$

and

$$\frac{\partial^2\phi}{\partial x_q\partial x_p} = \psi''(\rho)\,\frac{(x_q - x_q')(x_p - x_p')}{\rho^2}$$

$$+\ \psi'(\rho)\left[\delta_{(p,q)} - \frac{(x_p-x_p')(x_q-x_q')}{\rho^2}\right]\ . \tag{B.75}$$

Lemma B.4. If we assume that the penetrable dielectric is replaced by free space with an equivalent current distribution, then this distribution is given by

$$\vec{J}_{eq} = \left[\sigma(r) + i\omega(\varepsilon(r)-\varepsilon_0) \right]\vec{E} = \tau(r)\vec{E} \; . \tag{B.76}$$

Proof. Let us assume that we are in free space. Then the Maxwell equation becomes

$$\nabla \times \vec{H} - i\omega\varepsilon_0 \vec{E} = \vec{J}_{eq}. \tag{B.77}$$

However, the actual equation is

$$\nabla \times \vec{H} - i\omega\varepsilon\vec{E} = \sigma\vec{E} \; . \tag{B.78}$$

From (B.77) and (B.78) we deduce (B.76).

Thus,

$$\vec{E}^s(r) = PV \int_V \vec{J}_{eq}(r')\cdot G(r,r')dv(r') - \frac{\vec{J}_{eq}(r)}{3k\omega\varepsilon_0} \tag{B.79}$$

and

$$(\vec{E} - \vec{E}^i) = PV \int_V \tau(r') \vec{E}(r')\cdot G(r,r')dv(r') - \frac{\tau(r)\vec{E}(r)}{3j\omega\varepsilon_0} \tag{B.80}$$

which implies that

$$\left[1 + \frac{\tau(r)}{3i\omega\varepsilon_0} \right]\vec{E}(r) - PV\left\{ \int_V \tau(r')\vec{E}(r')\cdot G(r,r')dv(r') \right\} = \vec{E}^i(r) \tag{B.81}$$

APPENDIX C

DISCRETIZATION OF THE INTEGRAL EQUATION OF ELECTROMAGNETIC SCATTERING

We now carry out the discretization of the integral equation making full use of symmetry relations. The basic integral equation according to (B.69), (B.71) -(B.72), and (B.81) is

$$\left[1 + \frac{\tau(r)}{3i\omega\varepsilon_0}\right]\vec{E}(r) - PV\int_V \tau(r')\vec{E}(r')\cdot G(r,r')dv(r') = \vec{E}^i(r) , \tag{C.1}$$

where

$$G(r,r') = -i\omega\mu_0\left[I+(1/k_0^2)\text{grad}_r\text{grad}_r\right]\phi(r,r') . \tag{C.2}$$

Let us introduce some notation that will enable us to represent the dyadic in a compact form. We write

$$\rho = |r-r'| = \sqrt{(x_1-x_1')^2+(x_2-x_2')^2+(x_3-x_3')^2} , \tag{C.3}$$

$$\psi(\rho) = \phi(r,r') = \frac{\exp(-ik_0|r-r'|)}{4\pi|r-r'|} , \tag{C.4}$$

and

$$\Delta x_i = x_i - x_i' . \tag{C.5}$$

Thus, to compute $\text{grad}_r\text{grad}_r\psi$, we must compute $(\partial/\partial x_p)\psi$ and $(\partial^2/\partial x_p\partial x_q)\psi$.

Observe that

$$(\partial/\partial x_p)\psi(\rho) = (-ik_0 - \frac{1}{\rho})\,\psi(\rho)\,\frac{\Delta x_\rho}{\rho}$$

$$= \frac{\exp(-ik_0\rho)}{4\pi}\left[-ik_0\Delta x_p/\rho^2 - \Delta x_p/\rho^3\right] . \tag{C.6}$$

Also appearing in the Green's function are terms of the form $(\partial^2/\partial x_p\, \partial x_q)\psi(\rho)$. Observe that (C.6) implies that

$$\frac{\partial^2\psi}{\partial x_p \partial x_q} = (-ik_0 - 1/\rho)^2\psi(\rho)\left[\frac{\Delta x_p \Delta x_q}{\rho^2}\right]$$

$$+ (1/\rho^2)\psi(\rho)\left[\frac{\Delta x_p \Delta x_q}{\rho^2}\right] + (-ik_0 - 1/\rho)\psi(\rho)\left[\frac{\delta_{(p,q)}}{\rho}\right]$$

$$- (-ik_0 - 1/\rho)\psi(\rho)\,\frac{\Delta x_p \Delta x_q}{\rho^3} =$$

$$\left[-k_0^2 + \frac{2ik_0}{\rho} + \frac{1}{\rho^2} + \frac{1}{\rho^2} + \frac{ik_0}{\rho} + \frac{1}{\rho^2}\right]\psi(\rho)\,\frac{\Delta x_p \Delta x_q}{\rho^2}$$

$$+ (-ik_0 - 1/\rho)\psi(\rho)\left[\frac{\delta_{(p,q)}}{\rho}\right] =$$

$$\left[-k_0^2 + \frac{3}{\rho^2} + \frac{3ik_0}{\rho}\right]\psi(\rho)\,\frac{\Delta x_p \Delta x_q}{\rho^2} + (-ik_0 - 1/\rho)\psi(\rho)\left[\frac{\delta_{(p,q)}}{\rho}\right], \quad \text{(C.7)}$$

where $\delta_{(p,q)}$ is the Kronecker delta function.

Substituting the definition (C.4) into (C.7) we find that

$$\frac{\partial^2\psi}{\partial x_p \partial x_q} = (-k_0^2 + \frac{3}{\rho^2} + \frac{3ik_0}{\rho})\,\frac{\exp(-ik_0\rho)}{4\pi\rho}\,\frac{\Delta x_p \Delta x_q}{\rho^2}$$

$$- (ik_0/\rho + 1/\rho^2)\,\frac{\exp(-ik_0\rho)}{4\pi\rho}\,\delta_{(p,q)}\,. \quad \text{(C.8)}$$

Another representation of $(\partial^2/\partial x_p\, \partial x_q)\,\psi$ which is useful for integration is obtained by differentiating both sides of the expression

$$\frac{\partial\psi}{\partial x_p} = \psi'(\rho)\,\frac{\Delta x_p}{\rho} \quad \text{(C.9)}$$

with respect to x_q. We obtain the relation,

$$\frac{\partial^2\psi}{\partial x_q \partial x_p} = \Psi''(\rho)\,\frac{\Delta x_p \Delta x_q}{\rho^2} + \frac{\psi'(\rho)}{\rho}\left[\delta_{(p,q)} - \frac{\Delta x_p \Delta x_q}{\rho^2}\right]. \qquad (C.10)$$

Decompose the region V into subvolumes $\{V_1,\ldots,V_N\}$. We approximate (C.1) by the sums,

$$-\left[1 + \frac{\tau(r_m)}{3i\omega\varepsilon_0}\right]\vec{E}(r_m) + \sum_{\substack{n=1\\ n\neq m}}^{N} \tau(r_n')\,\vec{E}(r_n')\,G(r_m,r_n')V(r_n')$$

$$+ \int_0^{a_m}\int_0^{2\pi}\int_0^{\pi} \tau(\rho)\vec{E}(\rho)G(r_m,r_m')\rho^2 \sin\phi\, d\phi\, d\theta\, d\rho = -\vec{E}^i(r_m), \qquad (C.11)$$

where a_m is the radius of a sphere centered at r_m.

Let us write

$$R_{(m,n)} = |r_m - r_n|, \qquad (C.12)$$

$$\alpha_{(m,n)} = k_0 R_{(m,n)}, \qquad (C.13)$$

and

$$\cos\left[\theta_{x_p}^{(m,n)}\right] = \left[\frac{x_p^m - x_p^n}{R_{(m,n)}}\right], \qquad (C.14)$$

where $p \in \{1,2,3\}$.

Then (C.7) and $\rho = |r_m - r_n|$ imply that

$$(1/k_0^2)(\partial^2/\partial x_p \partial x_q)\,\psi(\rho) =$$

$$k_0\frac{\exp\left[-i\alpha_{(m,n)}\right]}{4\pi\alpha_{(m,n)}^3}\left[\left[-\alpha_{(m,n)}^2 + 3i\alpha_{(m,n)} + 3\right]\cos(\theta_{x_p}^{(m,n)})\cos(\theta_{x_q}^{(m,n)}) - (i\alpha_{(m,n)} + 1)\delta_{(p,q)}\right]. \qquad (C.15)$$

If we express (C.11) in the form

$$\sum_{q=1}^{3} \sum_{n=1}^{N} G^{(m,n)}_{(x_p,x_q)} \vec{E}_{x_q}(r_n) = \vec{E}^{i}(r_m), \tag{C.16}$$

then $m \neq n$ implies that

$$G^{(m,n)}_{(x_p,x_q)} = \frac{-i\omega\mu_0 k_0 \tau(r_n)}{4\pi\alpha^3_{(m,n)}} (V_n) \exp(-i(\alpha_{(m,n)})$$

$$\left[\frac{k_0^3 \ \rho^3}{k} \ \frac{1}{\rho} - (i\alpha_{(m,n)} + 1) \right] \delta_{(p,q)}$$

$$+ \left[3 - \alpha^2_{(m,n)} + 3i\alpha_{(m,n)}\right] \cos(\theta^{(m,n)}_{x_p}) \cos(\theta^{(m,n)}_{x_q}) \ . \tag{C.17}$$

From (C.17) we deduce the relation

$$G^{(m,n)}_{(x_p,x_q)} =$$

$$\frac{-i\omega\mu_0 k_0 \ \tau(r_n) V_n}{4\pi\alpha^{\ 3}_{(m,n)}} \ \exp(-i\alpha_{(m,n)}) \left[(\alpha^2_{(m,n)} - i\alpha_{(m,n)} - 1)\delta_{(p,q)} \right.$$

$$\left. + \left[3 - \alpha^2_{(m,n)} + 3i\alpha_{(m,n)}\right] \cos(\theta^{(m,n)}_{x_p}) \cos(\theta^{(m,n)}_{x_q}) \right] \tag{C.18}$$

for $m \neq n$.

We remind the reader of the relation,

$$\phi(r_n,r_n') = \frac{\exp(-ik \ |r_n-r_n'|)}{4\pi|r_n-r_n'|} = \psi(\rho) \ . \tag{C.19}$$

Then, the (n,n) entry of the coefficient matrix of (C.11) has the form

$$G^{(n,n)}_{(x_p,x_q)} = -\delta_{(p,q)}\left[1 + \frac{\tau(r_n)}{3i\omega\varepsilon_0}\right]$$

$$+ \tau(r_n)\ PV\int_{V_n}\left[-i\omega\mu_0\{\delta_{(p,q)} + \frac{1}{k_0^2}\left(\frac{\partial^2}{\partial x_p \partial x_q}\right)\}\phi(r_n,r')\right] dv(r'). \quad (C.20)$$

Here, we assume that V_n is replaced by a sphere of radius

$$a_n = \left(\frac{3V_n}{4\pi}\right)^{1/3} \quad (C.21)$$

and we carry out the integration in spherical coordinates.

We prove a series of lemmas in which we evaluate terms in the principal value integral defining the right side of (C.16).

<u>Lemma</u> C.1. <u>For every positive number</u> η <u>we have</u>

$$\int_\eta^{a_n}\int_0^\pi\int_0^{2\pi} \frac{\psi'(\rho)}{\rho}\rho^2 \sin\theta d\phi d\theta d\rho =$$

$$\left[\exp(-ik_0 a_n)-\exp(-ik_0\eta)\right] \quad -4\pi\int_\eta^{a_n}\psi(\rho)d\rho\ . \quad (C.22)$$

<u>Proof of Lemma</u> C.1. The integral is given by

$$I = \int_\eta^{a_n}\int_0^\pi\int_0^{2\pi}\left(\frac{\psi'(\rho)}{\rho}\right)\rho^2\sin\theta d\phi d\theta d\rho =$$

$$4\pi\int_\eta^{a_n}\psi'(\rho)\rho d\rho = 4\pi\int_{\rho=\eta}^{\rho=a_n}\rho d\psi(\rho), \quad (C.23)$$

which is the right side of (C.20).

Lemma C.2. For every positive number η we have

$$\int_{\eta}^{a_n}\int_0^{\pi}\int_0^{2\pi}\left[\frac{\psi''(\rho)}{\rho^2}\right]\Delta x_p \Delta x_q(\rho^2 \sin\theta)d\phi d\theta d\rho \quad =$$

$$(4\pi/3)\ \delta_{(p,q)}\left\{\frac{\exp(-ik_0\eta)[ik_0\eta+1] - \exp(ik_0a_n)\ [ik_0a_n+1]}{4\pi}\right.$$

$$-2\ \left[[\exp(-ik_0a_n) - \exp(-ik_0\eta)]/4\pi\right]$$

$$\left. + 2\int_{\eta}^{a_n}\psi(\rho)d\rho\right\}. \qquad (C.24)$$

Proof of Lemma C.2. Observe that

$$(\Delta x_1/\rho) \quad = \quad \sin\theta\cos\phi\ ,$$

$$(\Delta x_2/\rho) \quad = \quad \sin\theta\sin\phi\ ,$$

and

$$(\Delta x_3/\rho) \quad = \quad \cos\theta\ . \qquad (C.25)$$

Now we make use of another lemma which we use to prove Lemma C.2.

Lemma C.3. For all p and q we have

$$\int_0^{\pi}\int_0^{2\pi}\frac{\Delta x_p \Delta x_q}{\rho^2}\sin\theta d\phi d\theta \quad = \quad \delta_{(p,q)}4\pi/3\ . \qquad (C.26)$$

Proof of Lemma C.3. This follows from calculations used in establishing Lemma B.3 and from orthogonality relations.

Continuation of Proof of Lemma C.2. The integral I representing the left side of (C.24) is given by

$$I = (4\pi/3)\delta_{(p,q)}\int_{\eta}^{a_n}\psi''(\rho)\rho^2 d\rho\ . \qquad (C.27)$$

Integrating by parts we find that

$$I = (4\pi/3)\delta_{(p,q)} \left[\rho^2\psi'(\rho)\Big|_{\eta}^{a_n} - \int_{\eta}^{a_n} 2\rho\psi'(\rho)d\rho \right] . \tag{C.28}$$

Since by definition (C.4) and a direction calculation

$$\psi^1(\rho) = \frac{-\exp(-ik_0\rho)}{4\pi} \left[\frac{ik_0}{\rho} + \frac{1}{\rho^2} \right] , \tag{C.29}$$

(C.25) and Lemma C.1 imply that

$$I = (4\pi/3)\delta_{(p,q)} \left\{ \frac{-\exp(-k_0\rho)}{4\pi} \left[ik_0\rho+1 \right] \Bigg|_{\eta}^{an} \right.$$

$$\left. \frac{-2[\exp(-ik_0\rho)}{4\pi} \Bigg|_{\eta}^{a_n} + 2 \int_{\eta}^{a_n} \psi(\rho)d\rho \right\} . \tag{C.30}$$

Thus, we see that

$$\begin{aligned} I = (4\pi/3)\delta_{(p,q)} & \Big[-\exp(-ik_0a_n) \, [ik_0a_n+1] \\ & + \exp(-ik_0\eta) \, [ik_0\eta +1] \Big] \\ & -2[\exp(-ik_0a_n) - \exp(-ik_0\eta)]/(4\pi) \\ & + 2 \left(\int_{\eta}^{a_n} \psi(\rho)d\rho \right) . \end{aligned} \tag{C.31}$$

<u>Lemma</u> C.4. <u>For every positive number</u> η <u>we have</u>

$$\int_{\eta}^{a_n}\int_0^{\pi}\int_0^{2\pi} \frac{\psi'(p)}{\rho} \left[\frac{\Delta x_p \Delta x_q}{\rho^2} \right] \rho^2 \sin\theta d\phi d\theta d\rho =$$

$$(4\pi/3)\{\frac{[\exp(ik_0a_n) - \exp(-ik_0\eta)]}{4\pi} - \int_{\eta}^{a_n} \psi(\rho)d\rho\} . \tag{C.32}$$

Proof of Lemma C.4. This follows immediately from Lemma C.3 and the fact that

$$\int_{\eta}^{a_n} \psi'(\rho)\rho\, d\rho = \rho\psi(\rho)\Big|_{\eta}^{a_n} - \int_{\eta}^{a_n} \psi(\rho)d\rho .$$

Lemma C.5. For every positive number η, we have

$$\int_{B(a_n)} \psi(\rho)dv(\rho) = \left[\frac{a_n \exp(-ik_0 a_n)}{-ik_0} - \frac{\exp(-ik_0 a_n)}{-k_0^2} \right]$$

$$- \left[\frac{\eta \exp(-ik_0\eta)}{-ik_0} - \frac{\exp(-ik_0\eta)}{-k_0^2} \right] . \tag{C.33}$$

Proof of Lemma C.5. We have

$$\int_{\eta}^{a_n} \psi(\rho)\rho^2 d\rho = \int_{\eta}^{a_n} \left[\frac{\exp(-ik_0\rho)}{4\pi}\right]\rho d\rho . \tag{C.34}$$

Since

$$\int \exp(as)s\,ds = s\exp(as)/a - \exp(as)/a^2, \tag{C.35}$$

$$\int_{\eta}^{a_n} \psi(\rho)\rho^2 d\rho = \left(\frac{1}{4\pi}\right) \left[\frac{\rho\exp(-ik_0\rho)}{-ik_0} - \frac{\exp(-ik_0\rho)}{-k_0^2}\right]\Bigg|_{\eta}^{a_n} . \tag{C.36}$$

Theorem C.1. The principal value integral appearing as a term in the expression of the (n,n) entry of the coefficient matrix is defined by

$$I^n_{(p,q)} = \tau(r_n) PV \int_{V_n} \left\{ -i\omega\mu_o \left[\delta_{(p,q)} + (1/k_o^2)(\partial^2/\partial x_p \partial x_q) \right] \phi(r_n, r') \right\} dv(r')$$

$$= -\frac{2i\omega\mu_o \tau(r_n)}{3k_o^2} \delta_{(p,q)} [\exp(-ik_o a_n)\{ik_o a_n + 1\} - 1]. \qquad (C.37)$$

Proof of Theorem C.1. We need to evaluate

$$PV\int_{V_n} \tau(r_n)[-i\omega\mu_o \left[\delta_{(p,q)} + (1/k_o^2)(\partial^2/\partial x_p \partial x_q) \right] \phi(r_n, r')]dv(r')$$

$$-i\omega\mu_o \tau(r_n) PV \int_{V_n} \left[\delta_{(p,q)} + (1/k_o^2)(\partial^2/\partial x_p \partial x_q) \right] \phi(r_n, r') dv(r') \qquad (C.38)$$

Letting B_n be V_n with a ball of radius η removed, we use (C.10) to define

$$I_\eta = \int_{B_n} \left[\delta_{(p,q)} + (1/k_o^2)(\partial^2/\partial x_p \partial x_q) \right] \psi(\rho) dv(\rho)$$

$$= \delta_{(p,q)} \int_{B_n} \psi(\rho) dv(\rho) + (1/k_o^2) \int_{B_n} \psi''(\rho) \frac{\Delta x_p \Delta x_q}{\rho^2} dv(\rho)$$

$$+ (1/k_o^2) \delta_{(p,q)} \int_{B_n} \frac{\psi'(\rho)}{\rho} dv(\rho)$$

$$-(1/k_o^2) \int_{B_n} \frac{\psi'(\rho)}{\rho} \frac{\Delta x_p \Delta x_q}{\rho^2} dv(\rho) \qquad (C.39)$$

Using Lemma C.5, Lemma C.2, Lemma C.1, and Lemma C.4 as we proceed from left to right, we find that

$$I_\eta = \delta_{(p,q)}\left\{\left[\left[\frac{a_n \exp(-ik_0a_n)}{-ik_0} - \frac{\exp(-ik_0a_n)}{-k_0^2}\right]\right.\right.$$

$$\left.\left. - \left[\frac{\eta \exp(-ik_0\eta)}{-k_0} - \frac{\exp(-ik_0\eta)}{-k_0^2}\right]\right]\right\}$$

$$+ (1/3)\delta_{(p,q)} \left\{\exp(-ik_0\eta)\left[ik_0\eta+1\right] - \exp(-ik_0a_n)\left[ik_0a_n+1\right]\right.$$

$$\left. - 2(\exp(-ik_0a_n) - \exp(-ik_0\eta))\right\}\left(\frac{1}{k_0^2}\right)$$

$$+ \left(\frac{1}{k_0^2}\right)\delta_{(p,q)}(8\pi/3)\int_\eta^{a_n}\psi(\rho)d\rho$$

$$+\left(\frac{1}{k_0^2}\right)\delta_{(p,q)}\left[\exp(-ik_0a_n) - \exp(-ik_0\eta)\right] - 4\pi\left(\int_\eta^{a_n}\psi(\rho)d\rho\right)\delta_{(p,q)}\left(\frac{1}{k_0^2}\right)$$

$$-(1/3)\left[\exp(-ik_0a_n) - \exp(-ik_0\eta)\right]\delta_{(p,q)}\left(\frac{1}{k_0^2}\right)$$

$$+ (4\pi/3)\left(\int_\eta^{a_n}\psi(\rho)d\rho\right)\delta_{(p,q)}\left(\frac{1}{k_0^2}\right). \tag{C.40}$$

Collecting terms in (C.40) we observe that the terms involving the singular integral cancel out. We have

$$I_n = \delta_{(p,q)} \exp(-ik_0 a_n) \left[\frac{a_n}{-ik_0} + \frac{1}{k_0^2} - \left(\frac{ik_0 a_n+1}{k_0^2} \right) \left(\frac{1}{3} \right) \right.$$

$$\left. - \left(\frac{2}{3k_0^2} \right) + \frac{1}{k_0^2} - \frac{1}{3k_0^2} \right]$$

$$+ \delta_{(p,q)} \exp(-ik_0 \eta) \left[\frac{\eta}{ik_0} - \frac{1}{k_0^2} + \frac{i\eta}{3k_0} + \frac{1}{3k_0^2} \right.$$

$$\left. + \frac{2}{3k_0^2} - \frac{1}{k_0^2} + \frac{1}{3k_0^2} \right] . \tag{C.41}$$

Collecting terms still further we have

$$I_n = \delta_{(p,q)} \exp(-ik_0 a_n) \left[\frac{2ia_n}{3k_0} + \frac{2}{3k_0^2} \right]$$

$$+ \delta_{(p,q)} \exp(-ik_0 \eta) \left[\frac{-2i\eta}{3k_0} - \frac{2}{3k_0^2} \right] . \tag{C.42}$$

Taking the limit as $\eta \to 0$ we find that

$$\lim_{\eta \to 0} I_\eta = \left(\frac{2}{3k_0^2} \right) \delta_{(p,q)} \exp(-ik_0 a_n) [ik_0 a_n + 1] - \left(\frac{2}{3k_0^2} \right) . \tag{C.43}$$

APPENDIX D

UTILIZATION OF SYMMETRY GROUPS IN SIMPLIFYING THE INTEGRAL EQUATION

Define a group G generated by the operations I, R_1, R_2, and R_3 where

$$R_1(x_1,x_2,x_3) = (-x_1,x_2,x_3), \tag{D.1}$$

$$R_2(x_1,x_2,x_3) = (x_1,-x_2,x_3), \tag{D.2}$$

and

$$R_3(x_1,x_2,x_3) = (x_1,x_2,-x_3). \tag{D.3}$$

Then the multiplication table for the group is given in Table D.1.

TABLE D-1. THE SYMMETRY GROUP MULTIPLICATION TABLE

	I	R_1	R_2	R_3	R_1R_2	R_1R_3	R_2R_3	$R_1R_2R_3$
I	I	R_1	R_2	R_3	R_1R_2	R_1R_3	R_2R_3	$R_1R_2R_3$
R_1	R_1	I	R_1R_2	R_1R_3	R_2	R_3	$R_1R_2R_3$	R_2R_3
R_2	R_2	R_1R_2	I	R_2R_3	R_1	$R_1R_2R_3$	R_3	R_1R_3
R_3	R_3	R_1R_3	R_2R_3	I	$R_1R_2R_3$	R_1	R_2	R_1R_2
R_1R_2	R_1R_2	R_2	R_1	$R_1R_2R_3$	I	R_2R_3	R_1R_3	R_3
R_1R_3	R_1R_3	R_3	$R_1R_2R_3$	R_1	R_2R_3	I	R_1R_2	R_2
R_2R_3	R_2R_3	$R_1R_2R_3$	R_3	R_2	R_1R_3	R_1R_2	J	R_1
$R_1R_2R_3$	$R_1R_2R_3$	R_2R_3	R_1R_3	R_1R_2	R_3	R_2	R_1	I

Let

$$G = \{I,R_1,R_2,R_3,R_1R_2,R_1R_3,R_2R_3,R_1R_2R_3\}. \tag{D.4}$$

The transformation group whose multiplication group is given in Table D-1 simply permutes the octants depicted in Figure D-1.

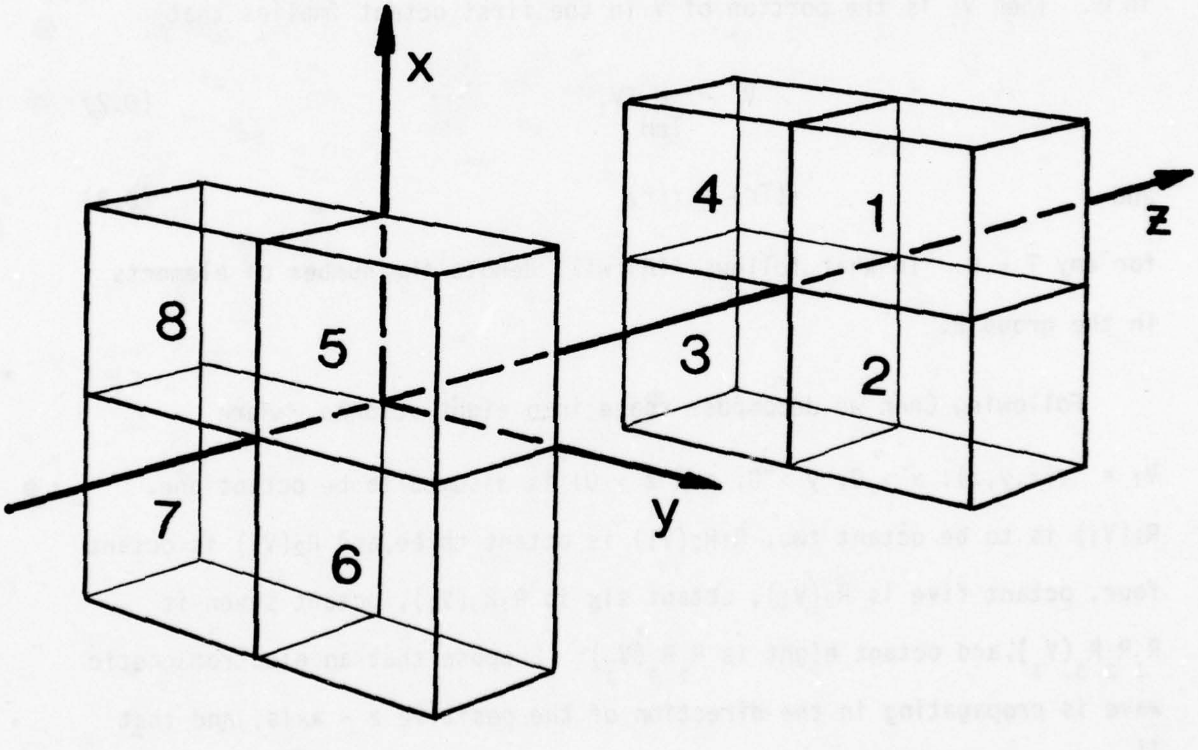

Figure D-1. Division of space into octants.

The basic integral equation is

$$\left[I + \frac{\tau(r)}{3i\omega\,\epsilon_0} \right] \vec{E}(r) - PV \int_V \tau(r')\, \vec{E}(r') \cdot G(r,r')\, dv(r') = \vec{E}^i(r) \ . \qquad (D.5)$$

Assume that for all $T \varepsilon G$, that

$$G(Tr,Tr') = G(r,r') \cdot \qquad (D.6)$$

Assume that region V is invariant under a subgroup H of transformations in G. Then V_1 is the portion of V in the first octant implies that

$$V = \bigcup_{T \varepsilon H} TV_1 \qquad (D.7)$$

and

$$\tau(Tr) = \tau(r) \qquad (D.8)$$

for any $T \varepsilon H$. In what follows #(H) will denote the number of elements in the group H.

Following Chen we decompose space into eight octants. Here $V_1 = \{(x,y,z): x > 0,\ y > 0, \text{ and } z > 0\}$ is assumed to be octant one, $R_1(V_1)$ is to be octant two, $R_1R_2(V_1)$ is octant three, and $R_2(V_1)$ is octant four, octant five is $R_3(V_1)$, octant six is $R_1R_3(V_1)$, octant seven is $R_1R_2R_3(V_1)$, and octant eight is $R_2R_3(V_1)$. Suppose that an electromagnetic wave is propagating in the direction of the positive z - axis, and that $\vec{E}^i$ is a function of z and t only and is polarized so that $\vec{E}^i$ is parallel to the positive x - axis.

Suppose that

$$\vec{E}^i = \vec{C}^i + \vec{S}^i \ , \qquad (D.9)$$

where $\vec{E}^i$ is assumed to depend only on z. Thus,

$$\vec{C}^i(z) = (\vec{E}^i(z) + \vec{E}^i(-z))/2 \tag{D.10}$$

and

$$\vec{S}^i(z) = (\vec{E}^i(z) - \vec{E}^i(-z))/2 \,. \tag{D.11}$$

Then

$$\vec{C}^i(z) = \vec{C}^i(-z) \tag{D.12}$$

and

$$\vec{S}^i(z) = -\vec{S}^i(-z). \tag{D.13}$$

From (D.5) and (D.7) we deduce that

$$\left[1 + \frac{\tau(r)}{3i\omega\varepsilon_0}\right]\vec{E}(r) - \sum_{T\varepsilon H}\left\{PV\int_{T(V_1)} \tau(r')\vec{E}(r')\cdot G(r,r')\,dv(r')\right\} = \vec{E}^i(r). \tag{D.14}$$

Letting $r' = T\,\xi'$, we deduce that

$$\left[1 + \frac{\tau(r)}{3i\omega\varepsilon_0}\right]\vec{E}(r) - \sum_{T\varepsilon H}\left\{PV\int_{V_1} \tau(\xi')\,\vec{E}(T\xi')\,G(r,T\xi')dv(\xi')\right\} = \vec{E}^i(r)\,, \tag{D.15}$$

$$\left[1 + \frac{\tau(r)}{3i\omega\,\varepsilon_0}\right]\vec{E}(Sr) - \sum_{T\varepsilon H}\left\{PV\int_{V_1} \tau(\xi')\,\vec{E}(T\xi')\,G(Sr,T\xi')dv(\xi')\right\} = \vec{E}^i(Sr)\,. \tag{D.16}$$

Now there are two possibilities. Let us define

$$\vec{C}^i(r) = (1/\#(H))\,\left(\sum_{S\varepsilon H}\vec{C}^i(Sr)\right) \tag{D.17}$$

and

$$\vec{S}^i(r) = (1/\#(H))\left\{\sum_{S\varepsilon H} C_S\vec{S}^i(Sr),\ \text{where } C_S = +1 \text{ when } Sr = (x,y,z) \Rightarrow z > 0,\right.$$

$$\left. C_S = -1 \text{ when } Sr = (x,y,z) \Rightarrow z < 0 \text{ if } r \text{ is in the first octant}\right\}. \tag{D.18}$$

Note that if we define an operator L_C by the rule

$$L_C\vec{F}(r) = (\sum_{S\varepsilon H} \vec{F}(Sr)/\#(H) , \tag{D.19}$$

and an operator L_S in a similar way using (D.18), then

$$\vec{E}^i(r) = \vec{C}^i(r) + \vec{S}^i(r) = L_C\vec{C}^i(r) + L_S\vec{S}^i(r) \tag{D.20}$$

<u>Lemma</u> D.1. <u>For every</u> $T \varepsilon H$, $\sum_{S\varepsilon H} G(Sr,T\xi') = \sum_{S\varepsilon H} G(Sr,\xi')$. (D.21)

<u>Proof of Lemma</u> D.1.

Observe that

$$\sum_{S\varepsilon H} G(Sr,T\xi') = \sum_{S\varepsilon H} G(TTSr,T\xi') = \sum_{S\varepsilon H} g(TSr,\xi') \tag{D.22}$$

by (D.6). But as S runs over H, so does TS. Hence, (D.22) implies that (D.21) is correct.

<u>Theorem</u> D.1. <u>Let us define</u>

$$\vec{\Psi}(r) = \sum_{S\varepsilon H} \vec{E}_C(Sr)/\#(H) .$$

where $\vec{E}_C$ is the solution of (D.5) obtained when $\vec{E}^i$ is replaced by $\vec{C}^i$. Then

$$\left[1 + \frac{\tau(r)}{3i\omega\varepsilon_0}\right] \vec{\Psi}(r) - PV \int_{V_1} \tau(\xi')\vec{\Psi}(\xi') \left(\sum_{S\varepsilon H} G(Sr,\xi')\right) dv(\xi') = \vec{C}^i(r) . \tag{D.23}$$

<u>Proof of Theorem</u> D.1. This is an immediate consequence of Lemma D.1 and equation (D.17) which defines (D.23).

<u>Lemma</u> D.2. <u>Let us define</u> C_T <u>for every</u> T <u>in the subgroup</u> H <u>of isometries of</u> $\mathcal{R}^3$ <u>according to</u> (D.18). <u>Then</u>

$$\sum_{S\varepsilon H} C_S\, G(Sr,T\xi') = C_T \sum_{S\varepsilon H} C_S G(Sr,\xi') . \tag{D.24}$$

Proof of Lemma D.2. Observe that

$$\sum_{S\varepsilon H} C_S\ G(Sr,T\xi') = \sum_{S\varepsilon H} C_S\ G(TTSr,T\xi') = \sum_{S\varepsilon H} C_S G(TSr,\xi'). \tag{D.25}$$

Since $C_T = 1$ and $C_{TS} = C_T C_S$, (D.25) implies that

$$\sum_{S\varepsilon H} C_S G(Sr_1 T\xi') = C_T \sum_{S\varepsilon H} C_{TS}\ G(TSr_1\xi'). \tag{D.26}$$

Since as S runs over H, TS also runs over H, equation (D.26) implies (D.24).

Theorem D.2. Let us define

$$\vec{\Phi}(r) = \left[\sum_{S\varepsilon H} C_S \vec{E}_S(Sr)\right]/\#(H). \tag{D.27}$$

where $\vec{E}_S$ is the solution of (D.5) obtained by replacing $\vec{E}^i$ by $\vec{S}^i$. Then

$$\left[1 + \frac{\tau(r)}{3i\omega\varepsilon_0}\right]\vec{\Phi}(r) - PV\int_{V_1} \tau(\xi')\vec{\Phi}(\xi') \sum_{S\varepsilon H} C_S G(Sr,\xi')dv(\xi') = \vec{S}^i(r). \tag{D.28}$$

Proof. Multiplying all terms of (D.16) by C_S and summing over S in H and dividing by #(H), we deduce that

$$\left[1 + \frac{\tau(r)}{3i\omega\varepsilon_0}\right]\vec{\Phi}(r) - \sum_{T\varepsilon H}\left(PV\int_{V_1}\left[\frac{\tau(\xi')\vec{E}(T\xi')}{\#(H)} \sum_{S\,\varepsilon\, H} C_S G(Sr,T\xi')\right]dv(\xi')\right)$$

$$= \vec{S}^i(r)\ . \tag{D.29}$$

From Lemma D.2 we deduce that

$$\left[1 + \frac{\tau(r)}{3i\omega\varepsilon_0}\right]\vec{\Phi}(r) - \sum_{T\varepsilon H}\left(PV\int_{V_1}\left[\frac{\tau(\xi')C_T\vec{E}(T\xi')}{\#(H)} \sum_{S\,\varepsilon\, H} C_S G(Sr,\xi')\right]dv(\xi')\right)$$

$$= \vec{S}^i(r) \tag{D.30}$$

which immediately yields (D.28).

We note now that $\vec{\Psi}$ satisfies the same integral equation that is satisfied by $\vec{E}_C$. By the uniqueness theorem we see that $\vec{E}_C$ must be equal to $\vec{\Psi}$. Note however that the fact that $\vec{\Psi}(Tr) = \vec{\Psi}(r)$ for every T in H implies that the same is true of $\vec{E}_C$. This means that we can completely determine all values of $\vec{E}_C$ just by solving an integral equation involving integrals over part of the first octant.

Secondly, observe that $\vec{\Phi}$ satisfies the same integral equation that is satisfied by $\vec{E}_S$. By the same reasoning we conclude that $\vec{E}_S = \vec{\Phi}$ everywhere in V. We observe that if r is in the first octant, then $\vec{\Phi}(Tr) = C_T\vec{\Phi}(r)$ for every transformation T in H. This being true of $\vec{E}_S$ as well enables us to deduce the value of $\vec{E}_S$ in any octant just by knowing its value in the first octant.

Finally, since $\vec{E} = \vec{E}_C + \vec{E}_S$, we see that we may determine the value of $\vec{E}$ in any octant simply by knowing the values of $\vec{E}_C$ and $\vec{E}_S$ in the first octant.

Exercise D.1. <u>Reconstruct the integral equation satisfied by $\vec{E}_C$ from the integral equation satisfied by $\vec{\Psi}$.</u>

<u>Solution of Exercise</u> D.1. Observe that since $S^2 = I$ that

$$C^i(r) - \left(1 + \frac{\tau(r)}{3i\omega\varepsilon_0}\right)\vec{\Psi}(r) =$$

$$-PV\int_{V_1} \tau(r')\vec{\Psi}(r') \sum_{S\varepsilon H} G(Sr,r')dv(r') =$$

$$-PV\int_{V_1} \tau(r')\vec{\Psi}(r') \sum_{S\varepsilon H} G(SSr,Sr')dv(r') =$$

$$-\sum_{S\varepsilon H} PV\int_{V_1} \tau(Sr')\vec{\Psi}(Sr')G(r,Sr')dv(Sr') \ . \qquad (D.31)$$

Exercise D.2. Reconstruct the integral equation satisfied by $\vec{E}_S$ from the integral equation satisfied by $\vec{\Phi}$.

Solution of Exercise D.2. We observe that since $S^2 = I$ and $C_S\vec{\Phi}(Sr') = \vec{\Phi}(r')$, we see that

$$\vec{S}^i(r) - \left(1 + \frac{\tau(r)}{3i\omega\varepsilon_0}\right)\vec{\Phi}(r) =$$

$$-PV\int_{V_1} \tau(r')\vec{\Phi}(r') \sum_{S\varepsilon H} C_S G(Sr,r')dv(r') =$$

$$-\sum_{S\varepsilon H} PV\int_{V_1} \tau(Sr')\vec{\Phi}(Sr')C_S G(SSr,Sr')dv(Sr') =$$

$$-PV\int_{V} \tau(r')\vec{\Phi}(r')G(r,r')dv(r') \,, \qquad \text{(D.32)}$$

which is exactly the integral equation that was originally satisfied by $\vec{E}_S$.

Thus, Exercises D.1 and D.2 give us proofs of the fact that $\vec{E}_C = \vec{\Psi}$ and $\vec{E}_S = \vec{\Phi}$ and shed light on the connection between the integral equations involving integrals over V_1, the part of the scattering obstacle that is in the first octant, and the integral equations involving integrals over the entire scatterer.

APPENDIX E

SAMPLE PROBLEMS WITH COMPUTER RESULTS

In this section we describe a numerical check of the program's validity. We approximate a ten-centimeter-diameter sphere filled with biological material by a complex of 528 one-centimeter cubes. Each of these cubes is filled with a biological material whose electrical properties are identical to that of the material filling the homogeneous sphere being approximated. We use the Mie solution (developed by Professor Gustav Mie in 1908) to compute the power density at values of r, θ, and ϕ corresponding to the centers of the cubes (Stratton [6], pp.563-570).

We describe here the results of two numerical experiments. The first experiment is scattering by a transparent region bounded by a sphere, and the second problem considers a translucent region delimited by a sphere.

In the transparent-sphere problem a sphere with zero conductivity and a relative dielectric constant of one was struck by a plane wave with a frequency of 1000 megahertz and a strength of one volt per meter. The problem was solved by the computer program implementing the technique described in this paper. The Mie-solution method was also used. The y and z components of the electric vector computed by the Mie-solution program are 14 orders of magnitude smaller than the x component determined by this program. In the integral equation program described in this paper the y and z components of the electric vector are found to be identically zero, which is their correct value. The approximating cubes found in the first octant of three-dimensional space are called cells; there are 66 cubes in the first octant that are used in approximating the scatterer. Both the Mie-solution program and the integral equation program are used to compute the fields at the centers of these cubes; the results obtained by the two methods are listed in Table E-1. In this table we list the real and imaginary parts of the x component of the electric vector that was computed by the two methods.

TABLE E-1. THE TRANSPARENT SPHERE

CELL NUMBER	INDUCED FIELD PREDICTED BY INTEGRAL EQUATION METHOD Re(E_x)	Im(E_x)	INDUCED FIELD PREDICTED BY MIE SOLUTION METHOD Re(E_x)	Im(E_x)
1	.9954	-.1046	.9945	-.1046
2	.9510	-.3093	.9510	-.3092
3	.8658	-.5004	.8658	-.5003
4	.7427	-.6696	.7428	-.6695
5	.5872	-.8095	.5873	-.8094
6	.9954	-.1046	.9945	-.1046
7	.9510	-.3093	.9510	-.3092
8	.8658	-.5004	.6858	-.5003
9	.7428	-.6696	.7428	-.6695
10	.5872	-.8095	.5873	-.8094
11	.9954	-.1046	.9945	-.1046
12	.9510	-.3093	.9510	-.3092
13	.8658	-.5004	.8658	-.5003
14	.7427	-.6696	.7428	-.6695
15	.9945	-.1046	.9946	-.1046
16	.9510	-.3093	.9510	-.3092
17	.8658	-.5004	.8658	-.5003
18	.7427	-.6696	.7428	-.6695
19	.9945	-.1046	.9945	-.1046
20	.9510	-.3093	.9510	-.3092
21	.9945	-.1046	.9945	-.1046
22	.9510	-.3093	.9510	-.3092
23	.8658	-.5004	.8658	-.5003

TABLE E-1. (continued)

CELL NUMBER	INDUCED FIELD PREDICTED BY INTEGRAL EQUATION METHOD Re(E_x)	Im(E_x)	INDUCED FIELD PREDICTED BY MIE SOLUTION METHOD Re(E_x)	Im(E_x)
24	.7427	-.6696	.7428	-.6695
25	.5872	-.8095	.5873	-.8094
26	.9945	-.1046	.9945	-.1046
27	.9510	-.3093	.9510	-.3092
28	.8658	-.5004	.8658	-.5003
29	.7427	-.6696	.7428	-.6695
30	.5872	-.8094	.5873	-.8094
31	.9945	-.1046	.9945	-.1046
32	.9510	-.3093	.9510	-.3092
33	.8658	-.5004	.8658	-.5003
34	.7427	-.6696	.7428	-.6695
35	.9945	-.1046	.9945	-.1046
36	.9510	-.3093	.9510	-.3092
37	.8658	-.5004	.8658	-.5003
38	.9945	-.1046	.9945	-.1046
39	.9510	-.3093	.9510	-.3092
40	.9945	-.1046	.9945	-.1046
41	.9510	-.3093	.9510	-.3092
42	.8658	-.5004	.8658	-.5003
43	.7427	-.6696	.7428	-.6695
44	.9954	-.1046	.9945	-.1046
45	.9510	-.3093	.9510	-.3092
46	.8658	-.5004	.8658	-.5003
47	.7427	-.6696	.7428	-.6695
48	.9510	-.3093	.9510	-.3092
49	.9945	-.1046	.9945	-.1046
50	.8658	-.5004	.8658	-.5003
51	.9945	-.1046	.9945	-.1046

TABLE E-1. (continued)

CELL NUMBER	INDUCED FIELD PREDICTED BY INTEGRAL EQUATION METHOD Re(E_x)	Im(E_x)	INDUCED FIELD PREDICTED BY MIE SOLUTION METHOD Re(E_x)	Im(E_x)
52	.9510	-.3093	.9510	-.3092
53	.9945	-.1046	.9945	-.1046
54	.9510	-.3093	.9510	-.3092
55	.8658	-.5004	.8658	-.5004
56	.7427	-.6696	.7428	-.6695
57	.9945	-.1046	.9945	-.1046
58	.9510	-.3093	.9510	-.3092
59	.8658	-.5004	.8658	-.5003
60	.9945	-.1046	.9945	-.1046
61	.9510	-.3093	.9510	-.3092
62	.9945	-.1046	.9945	-.1046
63	.9945	-.1045	.9945	-.1046
64	.9510	-.3093	.9510	-.3092
65	.9945	-.1046	.9945	-.1046
66	.9510	-.3093	.9510	-.3092

In the next problem a plane wave with a frequency of 1000 megahertz strikes a ball whose radius is 5 centimeters, whose relative dielectric constant is ε = 1.015625 and whose conductivity is σ = .015625 mhos per meter. The results of the comparison of the results of the Mie-solution program and the integral-equation program described in this paper is found in Table E-2 which follows. In this table we list in addition to the real and imaginary parts of the x component of the electric vector the estimate of the power density in each cell obtained by using the values of E and H at the center of the cell. The power density is denoted by P_d in Table E-2.

TABLE E-2. THE TRANSLUCENT SPHERE

CELL NUMBER	INDUCED FIELD PREDICTED BY INTEGRAL EQUATION METHOD			INDUCED FIELD PREDICTED BY MIE SOLUTION METHOD		
	Re(E_x)	Im(E_x)	P_d	Re(E_x)	Im(E_x)	P_d
1	.9376	-.0964	.00694	.9389	-.0956	.00695
2	.8969	-.2941	.00690	.8978	-.2943	.00697
3	.8179	-.4745	.00698	.8181	-.4761	.00700
4	.7056	-.6310	.00700	.7048	-.6336	.00702
5	.5589	-.7655	.00701	.5639	-.7607	.00701
6	.9385	-.0913	.00695	.9398	-.0913	.00695
7	.8986	-.2886	.00696	.8992	-.2901	.00697
8	.8205	-.4685	.00697	.8201	-.4721	.00699
9	.7079	-.6267	.00698	.7071	-.6298	.00700
10	.5558	-.7669	.00701	.5665	-.7574	.00699
11	.9402	-.0814	.00695	.9415	-.0830	.00698
12	.9020	-.2781	.00696	.9019	-.2819	.00697
13	.8262	-.4562	.00696	.8237	-.4642	.00698
14	.7130	-.6163	.00694	.7116	-.6225	.00698
15	.9428	-.0673	.00698	.9440	-.0704	.00700
16	.9063	-.2658	.00697	.9060	-.2695	.00698
17	.8324	-.4468	.00697	.8291	-.4523	.00697
18	.7352	-.5838	.00688	.7183	-.6113	.00695
19	.9490	-.0597	.00706	.9472	-.5345	.00703
20	.9094	-.2661	.00701	.9111	-.2532	.00698
21	.9380	-.0948	.00694	.9394	-.0924	.00696
22	.8973	-.2928	.00696	.8988	-.2912	.00697
23	.8176	-.4739	.00698	.8195	-.4731	.00670
24	.7071	-.6271	.00698	.7065	-.6309	.00701
[illegible]	.5892	-.7328	.00691	.5659	-.7582	.00700
26	.9390	-.8994	.00695	.9402	-.0883	.00697

TABLE E-2. (continued)

CELL NUMBER	INDUCED FIELD PREDICTED BY INTEGRAL EQUATION METHOD Re(E_x)	Im(E_x)	P_d	INDUCED FIELD PREDICTED BY MIE SOLUTION METHOD Re(E_x)	Im(E_x)	P_d
27	.8988	-.2874	.00696	.9001	-.2871	.00697
28	.8207	-.4671	.00697	.8213	-.4692	.00699
29	.7119	-.6205	.00697	.7087	-.6272	.00700
30	.5837	-.7379	.00693	.5685	-.7549	.00698
31	.9406	-.8101	.00696	.9419	-.0799	.00698
32	.9020	-.2767	.00696	.9028	-.2789	.00698
33	.8271	-.4533	.00695	.8249	-.4614	.00698
34	.7241	-.6010	.00692	.7132	-.6199	.00698
35	.9413	-.0638	.00696	.9443	-.0675	.00700
36	.9065	-.2585	.00695	.9067	-.2667	.00698
37	.8352	-.4277	.00689	.8303	-.4496	.00696
38	.9423	-.0156	.00695	.9473	-.0510	.00704
39	.9114	-.2261	.00690	.9117	-.2505	.00699
40	.9390	-.0914	.00696	.9403	-.0862	.00697
41	.8984	-.2893	.00697	.9005	-.2851	.00698
42	.8200	-.4720	.00700	.8221	-.4674	.00699
43	.6906	-.6510	.00705	.7098	-.6255	.00700
44	.9395	-.0862	.00696	.9411	-.0819	.00698
45	.8991	-.2857	.00696	.9019	-.2809	.00698
46	.8219	-.4673	.00699	.8239	-.4634	.00699
47	.7082	-.6283	.00701	.7121	-.6218	.00699
48	.9431	-.0777	.00700	.9427	-.0737	.00699
49	.9032	-.2763	.00698	.9045	-.2728	.00698
50	.8268	-.4547	.00696	.8275	-.4556	.00698
51	.9496	-.0907	.00712	.9451	-.0614	.00701
52	.9078	-.2662	.00700	.9083	-.2607	.00698
53	.9405	-.0854	.00698	.9415	-.0771	.00699
54	.9001	-.2852	.00698	.9030	-.2762	.00698
55	.8353	-.4377	.00696	.8258	-.4589	.00699
56	.7048	-.6364	.00708	.7146	-.6177	.00698

TABLE E-2. (continued)

CELL NUMBER	INDUCED FIELD PREDICTED BY INTEGRAL EQUATION METHOD			INDUCED FIELD PREDICTED BY MIE SOLUTION METHOD		
	$Re(E_x)$	$Im(E_x)$	P_d	$Re(E_x)$	$Im(E_x)$	P_d
57	.9403	-.0826	.00697	.9423	-.0727	.00699
58	.8997	-.2891	.00699	.9044	-.2719	.00698
59	.8215	-.4702	.00702	.8277	-.4548	.00698
60	.9409	-.0409	.00695	.9439	-.0645	.00700
61	.9018	-.2796	.00698	.9070	-.2638	.00698
62	.9426	-.0704	.00702	.9461	-.0524	.00703
63	.9423	-.0556	.00698	.9429	-.0651	.00700
64	.9005	-.2905	.00702	.9062	-.2644	.00699
65	.9474	-.0863	.00709	.9438	-.0607	.00701
66	.9001	-.3136	.00713	.9076	-.2601	.00699

A complete error analysis of the integral-equation method, not attempted here, will be carried out in a future report.

In both of the numerical experiments described in this section, the coordinates of the outer edges of the cells is the same as that listed in the computer output in Appendix F, and this list is, thus, not repeated in this Appendix. Many parts of the program remain nearly identical to the one supplied by Professor Kun Mu Chen, and the authors express our gratitude to him for supplying the listing.

APPENDIX F

COMPUTER PRINTOUT OF PROGRAM WITH RESULTS

LISTING OF COMPUTER PROGRAM

```
//HBF16TG2 JOB (3H01,BC20,60,,,0010,1,Y,58),'HBM376@@10R COHOON',
// MSGLEVEL=(1,1),PRTY=5,TIME=56,MSGCLASS=A

// EXEC PLOTGCLG,REGION.GO=225K,TIME=56
//FORT.SYSIN DD *
      REAL*8 COMP,XYZCOM,XONLYC,XANDY,SCAT,EXPKZ,COSKZ,SINKZ,EINCX,TOTAL
      COMPLEX G(19701),E(198),C(198),BUF(500),FRONT,BACK,GMAT
      COMMON VOL(198,7),X0,Y0,Z0,START1,START2,START3,ADD1,ADD2,ADD3,C1,
     1C2,C3,C4,FK0,NDIV,IP,IQ,N
      INTEGER*2 IQD,IVI,BLNK
      DIMENSION IVI(8),JQ(8),IQD(8)
      DATA EXPKZ/'EXPKZ'/,COSKZ/'COSKZ'/,SINKZ/'SINKZ'/,EINCX/'EINCX'/,T
     1OTAL/'TOTAL'/,BLNK/' '/,XYZCOM/'X,Y,Z.'/,XONLYC/'X-ONLY'/,XANDY/'X
     1ANDY.'/
      DATA IVI/'1','2','3','4','5','6','7','8'/,PI/3.14159265358/,E0/8.8
     154E-12/,FMU0/1.257E-6/
C           READ FIRST DATA CARD FOR NDIV
      READ 5,NDIV
    5 FORMAT (I1)
C           READ 2ND CARD FOR COMPONENTS,QUADRANTS,FREQUENCY AND TYPE OF
C              INCIDENT ELECTRIC FIELD.
      READ 10,COMP,IQD,FMEG,SCAT
   10 FORMAT (A8,2X,8A1,2X,F10.0,10X,A5)
      IF (COMP.EQ.XONLYC) GO TO 20
      IF (COMP.EQ.XANDY) GO TO 25
      IF (COMP.EQ.XYZCOM) GO TO 30
      PRINT 15,COMP
   15 FORMAT ('0(',A6,') ERROR IN COLS 1-6 OF SECOND DATA CARD')
      GO TO 395
   20 NDIM=1
      GO TO 35
   25 NDIM=2
      GO TO 35
   30 NDIM=3
C           CHECK QUADRANT CODES
   35 IF (IQD(1).EQ.IVI(1)) GO TO 45
      PRINT 40
   40 FORMAT ('1QUADRANT CODES READ IN DO NOT INCLUDE QUADRANT 1')
      STOP
   45 ISW=0
      JQ(1)=1
      DO 55 I=2,8
      IF (IQD(I).EQ.IVI(I)) GO TO 50
      JQ(I)=0
      IF (IQD(I).NE.BLNK)ISW=1
      GO TO 55
   50 JQ(I)=I
   55 CONTINUE
      IF (ISW.EQ.0) GO TO 65
      PRINT 60,IQD,JQ
   60 FORMAT ('1QUADRANT CODE ERRORS. SET READ IS',10X,8(1X,A1)/24X,'SET
     1 USED IS',10X,8I2)
   65 IFRONT=JQ(5)+JQ(6)+JQ(7)+JQ(8)
      IBACK=JQ(1)+JQ(2)+JQ(3)+JQ(4)
      IF (SCAT.EQ.COSKZ) GO TO 75
      IF (SCAT.EQ.SINKZ) GO TO 80
      IF (SCAT.EQ.EINCX) GO TO 85
      IF (SCAT.EQ.EXPKZ) GO TO 90
      IF (SCAT.EQ.TOTAL) GO TO 95
      PRINT 70,SCAT
```

```
   70 FORMAT ('0(',A6,') ERROR IN COLS 41-46 OF SECOND DATA CARD.')
      GO TO 395
   75 ISCAT=1
      GO TO 105
   80 ISCAT=2
      GO TO 105
   85 ISCAT=3
      GO TO 105
   90 ISCAT=4
      GO TO 105
   95 IF (IFRONT.EQ.0) GO TO 100
      ISCAT=5
      GO TO 105
  100 SCAT=EXPKZ
      ISCAT=4
  105 IS1=ISCAT
      IF (IS1.NE.5) GO TO 110
      ISCAT=1
      SCAT=COSKZ
C            READ 3RD CARD FOR NUMBER OF CELLS IN X,Y,AND Z DIRECTIONS
  110 READ 115,NX,NY,NZ
  115 FORMAT (3(I2,3X))
C            READ 4TH CARD FOR THE TOTAL NUMBER OF CELLS IN THE BODY
      READ 120,NCELL
  120 FORMAT (I3)
      MA=NDIM*NCELL
      IF (MA.LE.198) GO TO 130
      PRINT 125,MA
  125 FORMAT ('-NUMBER OF DIMENSIONS TIMES NUMBER OF CELLS =',I4,' EXCED
     1ES PROGRAM DIMENSIONS')
      GO TO 395
  130 M1=(MA*(MA+1))/2.
      DO 135 I=1,MA
  135 E(I)=CMPLX(0.,0.)
C            PRINT TITLES
      PRINT 140
  140 FORMAT ('1',15X,'THE PARAMETERS OF EACH CELL AS READ IN ARE GIVEN
     1BELOW IN CMS.'/'-',6X,'N',8X,'AMX',11X,'AMY',11X,'AMZ',10X,'DXCM',
     110X,'DYCM',10X,'DZCM'/)
      OMEG=2.*PI*FMEG*1.E6
      FK0=OMEG*SQRT(FMU0*E0)
C            READ IN LOCATION AND ELECTRICAL PROPERTIES OF CELL M
      DO 170 M=1,NCELL
      READ 145,AMX,AMY,AMZ,RLEP1,SIG1,DXCM,DYCM,DZCM
  145 FORMAT (8F10.3)
      DYCM=DXCM
      DZCM=DXCM
      VOL(M,1)=(AMX-.5*DXCM)/100.
      VOL(M,2)=(AMY-.5*DYCM)/100.
      VOL(M,3)=(AMZ-.5*DZCM)/100.
      DELTAX=DXCM/100.
      DELTAY=DYCM/100.
      DELTAZ=DZCM/100.
      VOL(M,4)=DELTAX*DELTAY*DELTAZ
      VOL(M,5)=RLEP1
      VOL(M,6)=SIG1
      VOL(M,7)=DELTAX
      Z=VOL(M,3)*FK0
      GO TO (150,155,160,165),ISCAT
  150 E(M)=CMPLX(-COS(Z),0.)
```

```
      GO TO 170
  155 E(M)=CMPLX(0.,SIN(Z))
      GO TO 170
  160 E(M)=CMPLX(-1.,0.)
      GO TO 170
  165 E(M)=-CEXP(CMPLX(0.,-Z))
  170 PRINT 175,M,AMX,AMY,AMZ,DXCM,DYCM,DZCM
  175 FORMAT (I8,1PD15.4,5D14.4)
      PRINT 180
  180 FORMAT ('-',14X,'X,Y,Z CORRESPOND TO CENTRAL LOCATION OF EACH CELL
     1 IN METERS'/'-',6X,'N',9X,'X',13X,'Y',13X,'Z',10X,'VOLUME',10X,'EP
     1S',8X,'SIG(MHO/M)'/)
      DO 185 J=1,NCELL
      PRINT 175,J,(VOL(J,L),L=1,6)
  185 VOL(J,5)=(VOL(J,5)-1.)*OMEG*E0
C          PRINT THE INCIDENT FIELD VALUES AT THE CENTRAL LOCATION OF
C             EACH SMALL SUBVOLUME
C          PRINT FREQUENCY,MAXIMUM NUMBER OF DIMENSIONS OF BODY,TYPE OF
C             COMPONENTS,AND THE NUMBER OF QUADRANTS USED FOR SYMMETRY.
      PRINT 190,SCAT,FMEG,NX,NY,NZ,COMP,JQ,NDIV
  190 FORMAT ('1',9X,' THE INCIDENT FIELD IS OF THE FORM ',A8/'0',17X,'F
     1REQUENCY =',F12.6,' MHZ.',5X,'( NX =',I3,5X,'NY =',I3,5X,'NZ =',I3
     1,3H ) /'0',17X,' FIELD COMPONENTS= ',A6,5X,'QUADRANTS USED =',8I2/
     1'0',18X,'NUMBER OF PARTITIONS PER EDGE IN INTEGRATION =',I2/'0',14
     1X,'INCIDENT ELECTRIC FIELD HAS THE FOLLOWING COMPONENTS'/'0',12X,'
     1E INCIDENT X-DIRECTION',5X,'E INCIDENT Y-DIRECTION',5X,'EINCIDENT
     1Z-DIRECTION'/'0',7X,'N',7X,'REAL',10X,'IMAG',10X,'REAL',10X,'IMAG'
     1,10X,'REAL',10X,'IMAG'/)
      GO TO (195,210,220),NDIM
  195 DO 200 I=1,NCELL
  200 PRINT 205,I,E(I)
  205 FORMAT (I9,2X,1P6D14.4)
      GO TO 230
  210 DO 215 J=1,NCELL
      JPN=J+NCELL
  215 PRINT 205,J,E(J),E(JPN)
      GO TO 230
  220 DO 225 K=1,NCELL
      KPN=K+NCELL
      KNN=KPN+NCELL
  225 PRINT 205,K,E(K),E(KPN),E(KNN)
  230 GRID=NDIV
      GFACT=0.5*((1./GRID)-1.)
      C1=-2.*OMEG*FMU0/(3.*PK0*PK0)
      C2=3./(4.*PI)
      C3=3.*OMEG*E0
      C4=-OMEG*FMU0*PK0/(4.*PI*GRID**3)
C          CALCULATE THE G MATRIX
      J1=0
      I1=1
      DO 270 IP=1,NDIM
      DO 270 M=1,NCELL
      X0=VOL(M,1)
      Y0=VOL(M,2)
      Z0=VOL(M,3)
      K=(IP-1)*NCELL+M
      DO 270 IQ=IP,NDIM
      N1=1
      IF (IP.EQ.IQ)N1=M
      DO 270 N=N1,NCELL
```

```
      L=(IQ-1)*NCELL+N
      DELTAX=VOL(N,7)
      DELTAY=DELTAX
      DELTAZ=DELTAX
      STAPT1=GFACT*DELTAX
      STAPT2=GFACT*DELTAY
      START3=GFACT*DELTAZ
      ADD1=DELTAX/GRID
      ADD2=DELTAY/GRID
      ADD3=DELTAZ/GRID
      GO TO (235,240,245),IQ
  235 BACK=GMAT(JQ(1))+GMAT(JQ(2))+GMAT(JQ(3))+GMAT(JQ(4))
      FRONT=GMAT(JQ(5))+GMAT(JQ(6))+GMAT(JQ(7))+GMAT(JQ(8))
      GO TO 250
  240 BACK=GMAT(JQ(1))-GMAT(JQ(2))+GMAT(JQ(3))-GMAT(JQ(4))
      FRONT=GMAT(JQ(5))-GMAT(JQ(6))+GMAT(JQ(7))-GMAT(JQ(8))
      GO TO 250
  245 BACK=GMAT(JQ(1))-GMAT(JQ(2))-GMAT(JQ(3))+GMAT(JQ(4))
      FRONT=-GMAT(JQ(5))+GMAT(JQ(6))+GMAT(JQ(7))-GMAT(JQ(8))
  250 GO TO (255,260,255,255,265),IS1
  255 G(I1)=BACK+FRONT
      GO TO 270
  260 G(I1)=BACK-FRONT
      GO TO 270
  265 G(I1)=BACK+FPONT
      J1=J1+1
      BUF(J1)=BACK-FRONT
      IF (J1.LT.500) GO TO 270
      WRITE (9) (BUF(I),I=1,500)
      J1=0
  270 I1=I1+1
      IF (IS1.NE.5) GO TO 280
      IF (J1.EQ.0) GO TO 275
      WRITE (9) (BUF(I),I=1,J1)
  275 REWIND 9
C            CALCULATE THE INDUCED FIELDS
  280 CALL MATPCH(G,E,MA,1,IER,1.E-35)
      IF (IER.NE.0) GO TO 395
      PRINT 285
  285 FORMAT ('-',24X,'(INDUCED ELECTRIC FIELDS IN QUADRANT 1)'/ '0',16X
     1,'N',9X,'EX(V/M)',11X,'EY(V/M)',11X,'EZ(V/M)',5X,'PWR DEN (W/CU. M
     1ET.)'/)
      CALL PRSUB(E,NDIM,NCELL,POWT)
C            CHECK FOR CREATING TOTAL POWER
      IF (IS1.EQ.5) GO TO 305
      IF (IFRONT.NE.0) GO TO 395
      IF (IBACK.EQ.10) GO TO 290
      IF (IBACK.EQ.1.OR.IBACK.GT.5) GO TO 395
      XMUL=2.
      GO TO 295
  290 XMUL=4.
  295 POWT=XMUL*POWT
      PRINT 300,POWT
  300 FORMAT ('-TOTAL POWER IN THE BODY =',1PE15.5,' WATTS')
      GO TO 395
  305 SCAT=SINKZ
      DO 315 I=1,MA
      C(I)=E(I)
      IF (I.GT.NCELL) GO TO 310
      E(I)=CMPLX(0.,SIN(VOL(I,3)*FKO))
```

```
      GO TO 315
310   E(I)=CMPLX(0.,0.)
315   CONTINUE
      PRINT 190,SCAT,FMEG,NX,NY,NZ,COMP,JQ,NDIV
      GO TO (320,330,340),NDIM
320   DO 325 I=1,NCELL
325   PRINT 205,I,E(I)
      GO TO 350
330   DO 335 J=1,NCELL
      JPN=J+NCELL
335   PRINT 205,J,E(J),E(JPN)
      GO TO 350
340   DO 345 K=1,NCELL
      KPN=K+NCELL
      KNN=KPN+NCELL
345   PRINT 205,K,E(K),E(KPN),E(KNN)
350   I1=I1-1
      K2=0
355   K1=K2+1
      K2=K2+500
      IF (K2.GT.I1) K2=I1
      READ (9) (G(K),K=K1,K2)
      IF (K2.LT.I1) GO TO 355
      CALL MATPCH(G,E,MA,1,IER,1.E-35)
      IF (IER.NE.0) GO TO 395
      PRINT 285
      CALL PRSUB(E,NDIM,NCELL,POWT)
      DO 360 I=1,MA
      G(I)=E(I)+C(I)
360   E(I)=E(I)-C(I)
      PRINT 365,(JQ(I),I=5,8)
365   FORMAT ('1FIELDS IN FRONT LAYER  (OCTANTS',4I2,' )')
      PRINT 370,FMEG,NX,NY,NZ,COMP,JQ,NDIV
370   FORMAT (1H0,24X,'(INDUCED ELECTRIC FIELDS IN ONE OCTANT)'/'0',17X,
     1'FREQUENCY =',F12.6,' MHZ.',5X,'( NX =',I3,5X,'NY =',I3,5X,'NZ =',
     1I3,3H ) /'0',17X,' FIELD COMPONENTS= ',A6,5X,'QUADRANTS USED =',8I
     12/'0',18X,'NUMBER OF PARTITIONS PER EDGE IN INTEGRATION =',I2/'-',
     116X,'N',9X,'EX(V/M)',11X,'EY(V/M)',11X,'EZ(V/M)',5X,'PWR DEN (W/CU
     1. MET.)'/)
      CALL PRSUB(E,NDIM,NCELL,POWF)
      PRINT 375,(JQ(I),I=1,4)
375   FORMAT ('1FIELDS IN BACK LAYER  (OCTANTS',4I2,' )')
      PRINT 370,FMEG,NX,NY,NZ,COMP,JQ,NDIV
      CALL PRSUB(G,NDIM,NCELL,POWB)
      IF (IFRONT+IBACK.EQ.36) GO TO 385
      IF (IFRONT.EQ.11.AND.IBACK.EQ.3) GO TO 380
      IF (IFRONT.EQ.12.AND.IBACK.EQ.4) GO TO 380
      IF (IFRONT.EQ.13.AND.JQ(5).EQ.5.AND.IBACK.EQ.5) GO TO 380
      IF (IFRONT.NE.5.OR.IBACK.NE.1) GO TO 395
      XMUL=1.
      GO TO 390
380   XMUL=2.
      GO TO 390
385   XMUL=4.
390   POWT=XMUL*(POWF+POWB)
      PRINT 300,POWT
395   STOP
      END
      SUBROUTINE PRSUB(X,NDIM,NCELL,PTOT)
      COMPLEX X(1)
```

```
      COMMON VOL(198,7)
      PTOT=0.D0
      DO 20 M=1,NCELL
      EFA=CABS(X(M))
      IF (NDIM.EQ.1) GO TO 5
      J=M+NCELL
      EFB=CABS(X(J))
      IF (NDIM.EQ.2) GO TO 10
      K=J+NCELL
      EFC=CABS(X(K))
      GO TO 15
    5 EFB=0.D0
   10 EFC=0.D0
   15 PWR=0.5*VOL(M,6)*(EFA*EFA+EFB*EFB+EFC*EFC)
      PTOT=PTOT+PWR*VOL(M,4)
   20 PRINT 25,M,EFA,EFB,EFC,PWR
   25 FORMAT (I18,1P4D18.5)
      PRINT 30,PTOT
   30 FORMAT (1H-,18X,'TOTAL POWER ABSORBED IN THE FIRST OCTANT =',1PE14
     1.5,'  WATTS'/'-  N',4X,'EXREAL',6X,'EXIMAG',6X,'EX-ABS',3X,'THETA-
     1X',3X,'EYREAL',6X,'EYIMAG',6X,'EY-ABS',3X,'THETA-Y',3X,'EZREAL',6X
     1,'EZIMAG',6X,'EZ-ABS',2X,'THETA-Z'/)
C           PRINT REAL,IMAGINARY,ABS. VALUE AND PHASE ANGLE OF INDUCED
C             FIELD
      DO 70 M=1,NCELL
      GO TO (45,40,35),NDIM
   35 K=M+2*NCELL
      EFC=CABS(X(K))
      CALL ANGLES(X(K),EF3)
   40 J=M+NCELL
      EFB=CABS(X(J))
      CALL ANGLES(X(J),EF2)
   45 EFA=CABS(X(M))
      CALL ANGLES(X(M),EF1)
      GO TO (50,60,65),NDIM
   50 PRINT 55,M,X(M),EFA,EF1
   55 FORMAT (I4,3(1P3E12.4,0PF7.1))
      GO TO 70
   60 PRINT 55,M,X(M),EFA,EF1,X(J),EFB,EF2
      GO TO 70
   65 PRINT 55,M,X(M),EFA,EF1,X(J),EFB,EF2,X(K),EFC,EF3
   70 CONTINUE
      RETURN
      END
      FUNCTION GMAT(IQD)
      DIMENSION U(3)
      COMPLEX TAUN,FCTR1,FCTR2,EXPO,TOTAL,GMAT
      COMMON VOL(198,7),X0,Y0,Z0,START1,START2,START3,ADD1,ADD2,ADD3,C1,
     1C2,C3,C4,FK0,NDIV,IP,IQ,N
      IF (IQD.NE.0) GO TO 10
    5 GMAT=CMPLX(0.,0.)
      GO TO 80
   10 GO TO (15,20,25,30,35,40,45,50),IQD
   15 U(1)=X0-VOL(N,1)
      U(2)=Y0-VOL(N,2)
      U(3)=Z0-VOL(N,3)
      GO TO 55
   20 U(1)=X0+VOL(N,1)
      U(2)=Y0-VOL(N,2)
      U(3)=Z0-VOL(N,3)
```

```
      GO TO 55
   25 U(1)=XO+VOL(N,1)
      U(2)=YO+VOL(N,2)
      U(3)=ZO-VOL(N,3)
      GO TO 55
   30 U(1)=XO-VOL(N,1)
      U(2)=YO+VOL(N,2)
      U(3)=ZO-VOL(N,3)
      GO TO 55
   35 U(1)=XO-VOL(N,1)
      U(2)=YO-VOL(N,2)
      U(3)=ZO+VOL(N,3)
      GO TO 55
   40 U(1)=XO+VOL(N,1)
      U(2)=YO-VOL(N,2)
      U(3)=ZO+VOL(N,3)
      GO TO 55
   45 U(1)=XO+VOL(N,1)
      U(2)=YO+VOL(N,2)
      U(3)=ZO+VOL(N,3)
      GO TO 55
   50 U(1)=XO-VOL(N,1)
      U(2)=YO+VOL(N,2)
      U(3)=ZO+VOL(N,3)
   55 VN=VOL(N,4)
      TAUN=CMPLX(VOL(N,6),VOL(N,5))
      IF (U(1)*U(1)+U(2)*U(2)+U(3)*U(3).NE.0.) GO TO 60
      IF (IP.NE.IQ) GO TO 5
      FCTR1=CMPLX(0.,C1)*TAUN
      A=(C2*VN)**.3333333333333333
      EXPO=CEXP(CMPLX(0.,-FKO*A))
      FCTR2=EXPO*CMPLX(1.,FKO*A)-CMPLX(1.,0.)
      GMAT=FCTR1*FCTR2-CMPLX(1.,0.)-TAUN/CMPLX(0.,C3)
      GO TO 80
   60 TOTAL=CMPLX(0.,0.)
      U1MIN=U(1)+START1
      U2MIN=U(2)+START2
      U(3)=U(3)+START3
      DO 75 IZ=1,NDIV
      U(1)=U1MIN
      DO 70 IX=1,NDIV
      U(2)=U2MIN
      DO 65 IY=1,NDIV
      R=SQRT(U(1)*U(1)+U(2)*U(2)+U(3)*U(3))
      A=FKO*R
      ASQ=A*A
      FCTR1=CEXP(CMPLX(0.,-A))/(ASQ*A)
      FCTR2=(U(IP)*U(IQ)/(R*R))*CMPLX(3.-ASQ,3.*A)
      IF (IP.EQ.IQ) FCTR2=FCTR2-CMPLX(1.-ASQ,A)
      TOTAL=TOTAL+FCTR1*FCTR2
   65 U(2)=U(2)+ADD2
   70 U(1)=U(1)+ADD1
   75 U(3)=U(3)+ADD3
      GMAT=CMPLX(0.,C4*VN)*TAUN*TOTAL
   80 RETURN
      END
      SUBROUTINE MATPCH(A,B,N,M,IER,EP)
      COMPLEX A(1),B(N,M),S
      IER=0
      NM1=N-1
```

```
      I1=1
      I2=N
      DO 20 I=1,NM1
      C=CABS(A(I1))
      IF (C.LT.1.D-15) PRINT 5,I,A(I1)
    5 FORMAT ('0FOR ROW',I4,' PIVOT IS',1P2D12.4)
      IF (C.LT.EP) GO TO 25
      IP1=I+1
      I3=I1
      K1=I3+N-I+1
      DO 15 J=IP1,N
      I3=I3+1
      S=A(I3)/A(I1)
      J1=I3
      DO 10 K=J,N
      A(K1)=A(K1)-S*A(J1)
      J1=J1+1
   10 K1=K1+1
      DO 15 L=1,M
   15 B(J,L)=B(J,L)-S*B(I,L)
      I1=I1+I2
   20 I2=I2-1
      C=CABS(A(K1-1))
      IF (C.LT.1.D-15) PRINT 5,N,A(K1-1)
      I=N
      IF (C.GE.EP) GO TO 35
   25 IER=1
      PRINT 30,N,I
   30 FORMAT ('-THIS SYSTEM OF ORDER',I4,' IS SINGULAR FOR ROW',I4,'.'/'
     1 THE PROGRAM CANNOT HANDLE THIS CASE.')
      RETURN
   35 I3=(N*(N+1))/2
      I4=2
      DO 50 I=1,N
      K=N-I+1
      KP1=K+1
      DO 50 L=1,M
      S=0.D0
      IF (K.EQ.N) GO TO 45
      J1=I3+1
      DO 40 J=KP1,N
      S=S+A(J1)*B(J,L)
   40 J1=J1+1
   45 B(K,L)=(B(K,L)-S)/A(I3)
      I3=I3-I4
   50 I4=I4+1
      RETURN
      END
      SUBROUTINE ANGLES(X,EF)
      COMPLEX X
C           DETERMINE ANGLE BETWEEN REAL AND IMAGINARY PARTS OF EFIELD
      A=REAL(X)
      B=AIMAG(X)
      IF (B)  5,15,25
    5 IF (A.NE.0.) GO TO 10
      EF=-90.0
      GO TO 30
   10 EF=57.2957795131*ATAN2(B,A)
      GO TO 30
   15 IF (A.GE.0.) GO TO 20
```

```
      EF=-180.
      GO TO 30
   20 EF=0.
      GO TO 30
   25 IF (A.NE.0.) GO TO 10
      EF=90.
   30 RETURN
      END
//GO.FT09F001 DD UNIT=SYSDA,SPACE=(TRK,(10,5)),DISP=(NEW,PASS)
//GO.SYSIN DD *
1
X,Y,Z.     12345678        1000.          TOTAL
 5    5    5
 66
          1.         1.         1.  1.015625  0.015625        1.         1.         1.
          1.         1.         2.  1.015625  0.015625        1.         1.         1.
          1.         1.         3.  1.015625  0.015625        1.         1.         1.
          1.         1.         4.  1.015625  0.015625        1.         1.         1.
          1.         1.         5.  1.015625  0.015625        1.         1.         1.
          1.         2.         1.  1.015625  0.015625        1.         1.         1.
          1.         2.         2.  1.015625  0.015625        1.         1.         1.
          1.         2.         3.  1.015625  0.015625        1.         1.         1.
          1.         2.         4.  1.015625  0.015625        1.         1.         1.
          1.         2.         5.  1.015625  0.015625        1.         1.         1.
          1.         3.         1.  1.015625  0.015625        1.         1.         1.
          1.         3.         2.  1.015625  0.015625        1.         1.         1.
          1.         3.         3.  1.015625  0.015625        1.         1.         1.
          1.         3.         4.  1.015625  0.015625        1.         1.         1.
          1.         4.         1.  1.015625  0.015625        1.         1.         1.
          1.         4.         2.  1.015625  0.015625        1.         1.         1.
          1.         4.         3.  1.015625  0.015625        1.         1.         1.
          1.         4.         4.  1.015625  0.015625        1.         1.         1.
          1.         5.         1.  1.015625  0.015625        1.         1.         1.
          1.         5.         2.  1.015625  0.015625        1.         1.         1.
          2.         1.         1.  1.015625  0.015625        1.         1.         1.
          2.         1.         2.  1.015625  0.015625        1.         1.         1.
          2.         1.         3.  1.015625  0.015625        1.         1.         1.
          2.         1.         4.  1.015625  0.015625        1.         1.         1.
          2.         1.         5.  1.015625  0.015625        1.         1.         1.
          2.         2          1.  1.015625  0.015625        1.         1.         1.
          2.         2.         2.  1.015625  0.015625        1.         1.         1.
          2.         2.         3.  1.015625  0.015625        1.         1.         1.
          2.         2.         4.  1.015625  0.015625        1.         1.         1.
          2.         2.         5.  1.015625  0.015625        1.         1.         1.
          2.         3.         1.  1.015625  0.015625        1.         1.         1.
          2.         3.         2.  1.015625  0.015625        1.         1.         1.
          2.         3.         3.  1.015625  0.015625        1.         1.         1.
          2.         3.         4.  1.015625  0.015625        1.         1.         1.
          2.         4.         1.  1.015625  0.015625        1.         1.         1.
          2.         4.         2.  1.015625  0.015625        1.         1.         1.
          2.         4.         3.  1.015625  0.015625        1.         1.         1.
          2.         5.         1.  1.015625  0.015625        1.         1.         1.
          2.         5.         2.  1.015625  0.015625        1.         1.         1.
          3.         1.         1.  1.015625  0.015625        1.         1.         1.
          3.         1.         2.  1.015625  0.015625        1.         1.         1.
          3.         1.         3.  1.015625  0.015625        1.         1.         1.
          3.         1.         4.  1.015625  0.015625        1.         1.         1.
          3.         2.         1.  1.015625  0.015625        1.         1.         1.
          3.         2.         2.  1.015625  0.015625        1.         1.         1.
          3.         2.         3.  1.015625  0.015625        1.         1.         1.
```

3.	2.	4.	1.015625	0.015625	1.	1.	1.
3.	3.	1.	1.015625	0.015625	1.	1.	1.
3.	3.	2.	1.015625	0.015625	1.	1.	1.
3.	3.	3.	1.015625	0.015625	1.	1.	1.
3.	4.	1.	1.015625	0.015625	1.	1.	1.
3.	4.	2.	1.015625	0.015625	1.	1.	1.
4.	1.	1.	1.015625	0.015625	1.	1.	1.
4.	1.	2.	1.015625	0.015625	1.	1.	1.
4.	1.	3.	1.015625	0.015625	1.	1.	1.
4.	1.	4.	1.015625	0.015625	1.	1.	1.
4.	2.	1.	1.015625	0.015625	1.	1.	1.
4.	2.	2.	1.015625	0.015625	1.	1.	1.
4.	2.	3.	1.015625	0.015625	1.	1.	1.
4.	3.	1.	1.015625	0.015625	1.	1.	1.
4.	3.	2.	1.015625	0.015625	1.	1.	1.
4.	4.	1.	1.015625	0.015625	1.	1.	1.
5.	1.	1.	1.015625	0.015625	1.	1.	1.
5.	1.	2.	1.015625	0.015625	1.	1.	1.
5.	2.	1.	1.015625	0.015625	1.	1.	1.
5.	2.	2.	1.015625	0.015625	1.	1.	1.

560 RECORDS PRINTED

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RESULTS OF COMPUTER PROGRAM

THE PARAMETERS OF EACH CELL AS READ IN ARE GIVEN BELOW IN CMS.

N	AMX	AMY	AMZ	DXCM	DYCM	DZCM
1	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
2	1.0000E+00	1.0000E+00	2.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
3	1.0000E+00	1.0000E+00	3.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
4	1.0000E+00	1.0000E+00	4.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
5	1.0000E+00	1.0000E+00	5.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
6	1.0000E+00	2.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
7	1.0000E+00	2.0000E+00	2.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
8	1.0000E+00	2.0000E+00	3.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
9	1.0000E+00	2.0000E+00	4.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
10	1.0000E+00	2.0000E+00	5.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
11	1.0000E+00	3.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
12	1.0000E+00	3.0000E+00	2.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
13	1.0000E+00	3.0000E+00	3.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
14	1.0000E+00	3.0000E+00	4.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
15	1.0000E+00	4.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
16	1.0000E+00	4.0000E+00	2.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
17	1.0000E+00	4.0000E+00	3.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
18	1.0000E+00	4.0000E+00	4.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
19	1.0000E+00	5.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
20	1.0000E+00	5.0000E+00	2.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
21	2.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
22	2.0000E+00	1.0000E+00	2.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
23	2.0000E+00	1.0000E+00	3.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
24	2.0000E+00	1.0000E+00	4.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
25	2.0000E+00	1.0000E+00	5.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
26	2.0000E+00	2.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
27	2.0000E+00	2.0000E+00	2.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00

28	2.0000E+00	2.0000E+00	3.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
29	2.0000E+00	2.0000E+00	4.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
30	2.0000E+00	2.0000E+00	5.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
31	2.0000E+00	3.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
32	2.0000E+00	3.0000E+00	2.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
33	2.0000E+00	3.0000E+00	3.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
34	2.0000E+00	3.0000E+00	4.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
35	2.0000E+00	4.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
36	2.0000E+00	4.0000E+00	2.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
37	2.0000E+00	4.0000E+00	3.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
38	2.0000E+00	5.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
39	2.0000E+00	5.0000E+00	2.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
40	3.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
41	3.0000E+00	1.0000E+00	2.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
42	3.0000E+00	1.0000E+00	3.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
43	3.0000E+00	1.0000E+00	4.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
44	3.0000E+00	2.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
45	3.0000E+00	2.0000E+00	2.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
46	3.0000E+00	2.0000E+00	3.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
47	3.0000E+00	2.0000E+00	4.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
48	3.0000E+00	3.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
49	3.0000E+00	3.0000E+00	2.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
50	3.0000E+00	3.0000E+00	3.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
51	3.0000E+00	4.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
52	3.0000E+00	4.0000E+00	2.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
53	4.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
54	4.0000E+00	1.0000E+00	2.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
55	4.0000E+00	1.0000E+00	3.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
56	4.0000E+00	1.0000E+00	4.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
57	4.0000E+00	2.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
58	4.0000E+00	2.0000E+00	2.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
59	4.0000E+00	2.0000E+00	3.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
60	4.0000E+00	3.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
61	4.0000E+00	3.0000E+00	2.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
62	4.0000E+00	4.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
63	5.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
64	5.0000E+00	1.0000E+00	2.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
65	5.0000E+00	2.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
66	5.0000E+00	2.0000E+00	2.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00

X,Y,Z CORRESPOND TO CENTRAL LOCATION OF EACH CELL IN METERS

N	X	Y	Z	VOLUME	EPS	SIG(MHO/M)
1	5.0000E-03	5.0000E-03	5.0000E-03	1.0000E-06	1.0156E+00	1.5625E-02
2	5.0000E-03	5.0000E-03	1.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
3	5.0000E-03	5.0000E-03	2.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
4	5.0000E-03	5.0000E-03	3.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
5	5.0000E-03	5.0000E-03	4.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
6	5.0000E-03	1.5000E-02	5.0000E-03	1.0000E-06	1.0156E+00	1.5625E-02
7	5.0000E-03	1.5000E-02	1.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
8	5.0000E-03	1.5000E-02	2.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
9	5.0000E-03	1.5000E-02	3.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
10	5.0000E-03	1.5000E-02	4.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
11	5.0000E-03	2.5000E-02	5.0000E-03	1.0000E-06	1.0156E+00	1.5625E-02
12	5.0000E-03	2.5000E-02	1.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
13	5.0000E-03	2.5000E-02	2.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
14	5.0000E-03	2.5000E-02	3.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
15	5.0000E-03	3.5000E-02	5.0000E-03	1.0000E-06	1.0156E+00	1.5625E-02
16	5.0000E-03	3.5000E-02	1.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02

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17	5.0000E-03	3.5000E-02	2.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
18	5.0000E-03	3.5000E-02	3.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
19	5.0000E-03	4.5000E-02	5.0000E-03	1.0000E-06	1.0156E+00	1.5625E-02
20	5.0000E-03	4.5000E-02	1.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
21	1.5000E-02	5.0000E-03	5.0000E-03	1.0000E-06	1.0156E+00	1.5625E-02
22	1.5000E-02	5.0000E-03	1.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
23	1.5000E-02	5.0000E-03	2.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
24	1.5000E-02	5.0000E-03	3.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
25	1.5000E-02	5.0000E-03	4.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
26	1.5000E-02	1.5000E-02	5.0000E-03	1.0000E-06	1.0156E+00	1.5625E-02
27	1.5000E-02	1.5000E-02	1.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
28	1.5000E-02	1.5000E-02	2.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
29	1.5000E-02	1.5000E-02	3.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
30	1.5000E-02	1.5000E-02	4.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
31	1.5000E-02	2.5000E-02	5.0000E-03	1.0000E-06	1.0156E+00	1.5625E-02
32	1.5000E-02	2.5000E-02	1.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
33	1.5000E-02	2.5000E-02	2.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
34	1.5000E-02	2.5000E-02	3.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
35	1.5000E-02	3.5000E-02	5.0000E-03	1.0000E-06	1.0156E+00	1.5625E-02
36	1.5000E-02	3.5000E-02	1.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
37	1.5000E-02	3.5000E-02	2.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
38	1.5000E-02	4.5000E-02	5.0000E-03	1.0000E-06	1.0156E+00	1.5625E-02
39	1.5000E-02	4.5000E-02	1.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
40	2.5000E-02	5.0000E-03	5.0000E-03	1.0000E-06	1.0156E+00	1.5625E-02
41	2.5000E-02	5.0000E-03	1.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
42	2.5000E-02	5.0000E-03	2.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
43	2.5000E-02	5.0000E-03	3.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
44	2.5000E-02	1.5000E-02	5.0000E-03	1.0000E-06	1.0156E+00	1.5625E-02
45	2.5000E-02	1.5000E-02	1.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
46	2.5000E-02	1.5000E-02	2.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
47	2.5000E-02	1.5000E-02	3.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
48	2.5000E-02	2.5000E-02	5.0000E-03	1.0000E-06	1.0156E+00	1.5625E-02
49	2.5000E-02	2.5000E-02	1.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
50	2.5000E-02	2.5000E-02	2.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
51	2.5000E-02	3.5000E-02	5.0000E-03	1.0000E-06	1.0156E+00	1.5625E-02
52	2.5000E-02	3.5000E-02	1.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
53	3.5000E-02	5.0000E-03	5.0000E-03	1.0000E-06	1.0156E+00	1.5625E-02
54	3.5000E-02	5.0000E-03	1.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
55	3.5000E-02	5.0000E-03	2.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
56	3.5000E-02	5.0000E-03	3.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
57	3.5000E-02	1.5000E-02	5.0000E-03	1.0000E-06	1.0156E+00	1.5625E-02
58	3.5000E-02	1.5000E-02	1.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
59	3.5000E-02	1.5000E-02	2.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
60	3.5000E-02	2.5000E-02	5.0000E-03	1.0000E-06	1.0156E+00	1.5625E-02
61	3.5000E-02	2.5000E-02	1.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
62	3.5000E-02	3.5000E-02	5.0000E-03	1.0000E-06	1.0156E+00	1.5625E-02
63	4.5000E-02	5.0000E-03	5.0000E-03	1.0000E-06	1.0156E+00	1.5625E-02
64	4.5000E-02	5.0000E-03	1.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02
65	4.5000E-02	1.5000E-02	5.0000E-03	1.0000E-06	1.0156E+00	1.5625E-02
66	4.5000E-02	1.5000E-02	1.5000E-02	1.0000E-06	1.0156E+00	1.5625E-02

THE INCIDENT FIELD IS OF THE FORM COSKZ
FREQUENCY = 1000.00000 MHZ. (NX = 5 NY = 5 NZ = 5)
FIELD COMPONENTS= X,Y,Z. QUADRANTS USED = 1 2 3 4 5 6 7 8
NUMBER OF PARTITIONS PER EDGE IN INTEGRATION = 1
INCIDENT ELECTRIC FIELD HAS THE FOLLOWING COMPONENTS

N	E INCIDENT X-DIRECTION REAL	IMAG	E INCIDENT Y-DIRECTION REAL	IMAG	EINCIDENT Z-DIRECTION REAL	IMAG

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1	-9.9451E-01	0.0	0.0	0.0	0.0	0.0
2	-9.5098E-01	0.0	0.0	0.0	0.0	0.0
3	-8.6581E-01	0.0	0.0	0.0	0.0	0.0
4	-7.4274E-01	0.0	0.0	0.0	0.0	0.0
5	-5.8716E-01	0.0	0.0	0.0	0.0	0.0
6	-9.9451E-01	0.0	0.0	0.0	0.0	0.0
7	-9.5098E-01	0.0	0.0	0.0	0.0	0.0
8	-8.6581E-01	0.0	0.0	0.0	0.0	0.0
9	-7.4274E-01	0.0	0.0	0.0	0.0	0.0
10	-5.8716E-01	0.0	0.0	0.0	0.0	0.0
11	-9.9451E-01	0.0	0.0	0.0	0.0	0.0
12	-9.5098E-01	0.0	0.0	0.0	0.0	0.0
13	-8.6581E-01	0.0	0.0	0.0	0.0	0.0
14	-7.4274E-01	0.0	0.0	0.0	0.0	0.0
15	-9.9451E-01	0.0	0.0	0.0	0.0	0.0
16	-9.5098E-01	0.0	0.0	0.0	0.0	0.0
17	-8.6581E-01	0.0	0.0	0.0	0.0	0.0
18	-7.4274E-01	0.0	0.0	0.0	0.0	0.0
19	-9.9451E-01	0.0	0.0	0.0	0.0	0.0
20	-9.5098E-01	0.0	0.0	0.0	0.0	0.0
21	-9.9451E-01	0.0	0.0	0.0	0.0	0.0
22	-9.5098E-01	0.0	0.0	0.0	0.0	0.0
23	-8.6581E-01	0.0	0.0	0.0	0.0	0.0
24	-7.4274E-01	0.0	0.0	0.0	0.0	0.0
25	-5.8716E-01	0.0	0.0	0.0	0.0	0.0
26	-9.9451E-01	0.0	0.0	0.0	0.0	0.0
27	-9.5098E-01	0.0	0.0	0.0	0.0	0.0
28	-8.6581E-01	0.0	0.0	0.0	0.0	0.0
29	-7.4274E-01	0.0	0.0	0.0	0.0	0.0
30	-5.8716E-01	0.0	0.0	0.0	0.0	0.0
31	-9.9451E-01	0.0	0.0	0.0	0.0	0.0
32	-9.5098E-01	0.0	0.0	0.0	0.0	0.0
33	-8.6581E-01	0.0	0.0	0.0	0.0	0.0
34	-7.4274E-01	0.0	0.0	0.0	0.0	0.0
35	-9.9451E-01	0.0	0.0	0.0	0.0	0.0
36	-9.5098E-01	0.0	0.0	0.0	0.0	0.0
37	-8.6581E-01	0.0	0.0	0.0	0.0	0.0
38	-9.9451E-01	0.0	0.0	0.0	0.0	0.0
39	-9.5098E-01	0.0	0.0	0.0	0.0	0.0
40	-9.9451E-01	0.0	0.0	0.0	0.0	0.0
41	-9.5098E-01	0.0	0.0	0.0	0.0	0.0
42	-8.6581E-01	0.0	0.0	0.0	0.0	0.0
43	-7.4274E-01	0.0	0.0	0.0	0.0	0.0
44	-9.9451E-01	0.0	0.0	0.0	0.0	0.0
45	-9.5098E-01	0.0	0.0	0.0	0.0	0.0
46	-8.6581E-01	0.0	0.0	0.0	0.0	0.0
47	-7.4274E-01	0.0	0.0	0.0	0.0	0.0
48	-9.9451E-01	0.0	0.0	0.0	0.0	0.0
49	-9.5098E-01	0.0	0.0	0.0	0.0	0.0
50	-8.6581E-01	0.0	0.0	0.0	0.0	0.0
51	-9.9451E-01	0.0	0.0	0.0	0.0	0.0
52	-9.5098E-01	0.0	0.0	0.0	0.0	0.0
53	-9.9451E-01	0.0	0.0	0.0	0.0	0.0
54	-9.5098E-01	0.0	0.0	0.0	0.0	0.0
55	-8.6581E-01	0.0	0.0	0.0	0.0	0.0
56	-7.4274E-01	0.0	0.0	0.0	0.0	0.0
57	-9.9451E-01	0.0	0.0	0.0	0.0	0.0
58	-9.5098E-01	0.0	0.0	0.0	0.0	0.0

59	-8.6581E-01	0.0	0.0	0.0	0.0	0.0
60	-9.9451E-01	0.0	0.0	0.0	0.0	0.0
61	-9.5098E-01	0.0	0.0	0.0	0.0	0.0
62	-9.9451E-01	0.0	0.0	0.0	0.0	0.0
63	-9.9451E-01	0.0	0.0	0.0	0.0	0.0
64	-9.5098E-01	0.0	0.0	0.0	0.0	0.0
65	-9.9451E-01	0.0	0.C	0.0	0.0	0.0
66	-9.5098E-01	0.0	0.0	0.0	0.0	0.0

(INDUCED ELECTRIC FIELDS IN QUADRANT 1)

N	EX(V/M)	EY(V/M)	EZ(V/M)	PWR DEN (W/CU. MET.)
1	9.36983E-01	1.16650E-04	4.39036E-04	6.85888E-03
2	8.94267E-01	1.89245E-04	1.36992E-03	6.24777E-03
3	8.10833E-01	2.79607E-04	2.42584E-03	5.13637E-03
4	6.90702E-01	3.59075E-05	4.07694E-03	3.72724E-03
5	5.41293E-01	6.54701E-04	8.53704E-03	2.28962E-03
6	9.37540E-01	3.22093E-04	3.47573E-04	6.86704E-03
7	8.94753E-01	5.23571E-04	1.10161E-03	6.25456E-03
8	8.11256E-01	9.82629E-04	2.31154E-03	5.14174E-03
9	6.91577E-01	4.43049E-04	5.21494E-03	3.73676E-03
10	5.42220E-01	2.07056E-03	9.73820E-03	2.29767E-03
11	9.38720E-01	4.58801E-04	2.60130E-04	6.88433E-03
12	8.95901E-01	4.72050E-04	6.54227E-04	6.27062E-03
13	8.12224E-01	1.50959E-03	1.18478E-03	5.15399E-03
14	6.93112E-01	4.25664E-03	7.45053E-03	3.75373E-03
15	9.40945E-01	1.32281E-03	6.24912E-04	6.91703E-03
16	8.98753E-01	2.79019E-03	1.36109E-03	6.31068E-03
17	8.15822E-01	5.52306E-03	1.95875E-03	5.19999E-03
18	6.93695E-01	7.22310E-03	9.08337E-03	3.76053E-03
19	9.47652E-01	8.54136E-03	1.41916E-03	7.01655E-03
20	9.05425E-01	9.70663E-03	4.25449E-03	6.40551E-03
21	9.37518E-01	3.20135E-04	1.33964E-03	6.86673E-03
22	8.94834E-01	5.18340E-04	4.20401E-03	6.25583E-03
23	8.11453E-01	9.80719E-04	7.31504E-03	5.14461E-03
24	6.90141E-01	4.28729E-04	7.38442E-03	3.72148E-03
25	5.36415E-01	2.11039E-03	2.66135E-02	2.25355E-03
26	9.38123E-01	8.72901E-04	1.06094E-03	6.87560E-03
27	8.95280E-01	1.54425E-03	3.26270E-03	6.26203E-03
28	8.11692E-01	3.60583E-03	6.11035E-03	5.14761E-03
29	6.90967E-01	3.37922E-03	1.19471E-02	3.73116E-03
30	5.37748E-01	1.06205E-02	3.10874E-02	2.26759E-03
31	9.39293E-01	1.42178E-03	5.49487E-04	6.89276E-03
32	8.96235E-01	2.16457E-03	1.25287E-03	6.27533E-03
33	8.12878E-01	5.12383E-03	3.37099E-03	5.16256E-03
34	6.91937E-01	3.27664E-03	2.45949E-02	3.74525E-03
35	9.39204E-01	6.01696E-03	1.33553E-03	6.89173E-03
36	8.97248E-01	2.00605E-03	1.73026E-03	6.28953E-03
37	8.13797E-01	1.81314E-02	1.13791E-02	5.17753E-03
38	9.39014E-01	2.69704E-02	4.68448E-03	6.89451E-03
39	8.97802E-01	3.16571E-02	2.00170E-02	6.30822E-03
40	9.38562E-01	4.61018E-04	2.34492E-03	6.88206E-03
41	8.95691E-01	4.60514E-04	6.85448E-03	6.26804E-03
42	8.13771E-01	1.48904E-03	1.49228E-02	5.17537E-03
43	6.96442E-01	4.24109E-03	2.54309E-02	3.79450E-03
44	9.38968E-01	1.42547E-03	2.29610E-03	6.88803E-03
45	8.96337E-01	2.08380E-03	5.67485E-03	6.27700E-03
46	8.14186E-01	5.07354E-03	1.15139E-02	5.18014E-03
47	6.95028E-01	3.28972E-03	3.24640E-02	3.78225E-03

48	9.42282E-01	4.69308E-03	7.76984E-04	6.93685E-03
49	8.99119E-01	2.00579E-03	2.28812E-03	6.31581E-03
50	8.16453E-01	8.93940E-03	2.04557E-02	5.21167E-03
51	9.49551E-01	1.26333E-02	3.37574E-03	7.04545E-03
52	9.03383E-01	2.13066E-02	1.04336E-02	6.38018E-03
53	9.40319E-01	1.41982E-03	4.57470E-03	6.90798E-03
54	8.97150E-01	2.93085E-03	5.13910E-03	6.28838E-03
55	8.11288E-01	5.64438E-03	2.60089E-02	5.14763E-03
56	6.93177E-01	7.30701E-03	6.72053E-02	3.78956E-03
57	9.40161E-01	5.93225E-03	6.25174E-03	6.90607E-03
58	8.99076E-01	1.93610E-03	1.14184E-02	6.31618E-03
59	8.16778E-01	1.84258E-02	3.34787E-02	5.22333E-03
60	9.39014E-01	1.33850E-02	9.47949E-03	6.89075E-03
61	9.01823E-01	2.13939E-02	2.88708E-02	6.36388E-03
62	9.44651E-01	6.48831E-02	1.10014E-02	7.00544E-03
63	9.39642E-01	8.88738E-03	1.25473E-02	6.89971E-03
64	9.02452E-01	9.92238E-03	3.67473E-02	6.37398E-03
65	9.46530E-01	2.75204E-02	1.36353E-02	7.00673E-03
66	9.07039E-01	3.19773E-02	4.10464E-02	6.44865E-03

TOTAL POWEF ABSORBED IN THE FIRST OCTANT = 3.72098E-07 WATTS

N	EXREAL	EXIMAG	EX-ABS	THETA-X	EYREAL	EYIMAG	EY-ABS	THETA-Y	EZREAL	EZIMAG	EZ-ABS	THETA-Z
1	9.3696E-01	6.9349E-03	9.3698E-01	0.4	-1.0696E-04	4.6542E-05	1.1665E-04	156.5	-2.9490E-05	-4.3805E-04	4.3904E-04	-93.9
2	8.9419E-01	1.1421E-02	8.9427E-01	0.7	-1.2720E-04	1.4012E-04	1.8924E-04	132.2	-7.1942E-05	-1.3680E-03	1.3699E-03	-93.0
3	8.1060E-01	1.9589E-02	8.1083E-01	1.4	-1.3564E-04	2.4450E-04	2.7961E-04	119.0	-6.1610E-05	-2.4251E-03	2.4258E-03	-91.5
4	6.9005E-01	3.0096E-02	6.9070E-01	2.5	-3.5886E-05	1.2526E-06	3.5908E-05	178.0	2.0050E-04	-4.0720E-03	4.0769E-03	-87.2
5	5.4004E-01	3.6816E-02	5.4129E-01	3.9	-7.9135E-06	-6.5465E-04	6.5470E-04	-90.7	1.6673E-03	-8.3726E-03	8.5370E-03	-78.7
6	9.3746E-01	1.1979E-02	9.3754E-01	0.7	-3.0853E-04	9.2495E-05	3.2209E-04	163.3	-4.8175E-05	-3.4422E-04	3.4757E-04	-98.0
7	8.9460E-01	1.6785E-02	8.9475E-01	1.1	-3.7584E-04	3.6452E-04	5.2357E-04	135.9	-1.3846E-04	-1.0929E-03	1.1016E-03	-97.2
8	8.1086E-01	2.5396E-02	8.1126E-01	1.8	-4.6934E-04	8.6330E-04	9.8263E-04	118.5	-1.0093E-04	-2.3093E-03	2.3115E-03	-92.5
9	6.9071E-01	3.4710E-02	6.9158E-01	2.9	-6.2544E-05	4.3861E-04	4.4305E-04	98.1	6.0892E-04	-5.1793E-03	5.2149E-03	-83.3
10	5.4102E-01	3.5997E-02	5.4222E-01	3.8	8.9071E-05	-2.0686E-03	2.0706E-03	-87.5	1.5659E-03	-9.6115E-03	9.7382E-03	-80.7
11	9.3847E-01	2.1824E-02	9.3872E-01	1.3	-4.5876E-04	5.8766E-06	4.5880E-04	179.3	-4.3316E-05	-2.5650E-04	2.6013E-04	-99.6
12	8.9549E-01	2.7046E-02	8.9590E-01	1.7	-4.7068E-04	3.5942E-05	4.7205E-04	175.6	-2.1006E-04	-6.1959E-04	6.5423E-04	-108.7
13	8.1138E-01	3.7054E-02	8.1222E-01	2.6	-8.8866E-04	1.2203E-03	1.5096E-03	126.1	-5.2743E-04	-1.0609E-03	1.1848E-03	-116.4
14	6.9165E-01	4.5044E-02	6.9311E-01	3.7	-1.6734E-03	3.9139E-03	4.2566E-03	113.1	1.6570E-03	-7.2639E-03	7.4505E-03	-77.2
15	9.4026E-01	3.6006E-02	9.4095E-01	2.2	-1.6400E-04	-1.3126E-03	1.3228E-03	-97.1	1.0288E-04	-6.1639E-04	6.2491E-04	-80.5
16	8.9788E-01	3.9523E-02	8.9875E-01	2.5	3.5281E-04	-2.7678E-03	2.7902E-03	-82.7	3.2454E-04	-1.3218E-03	1.3611E-03	-76.2
17	8.1448E-01	4.6824E-02	8.1582E-01	3.3	1.4232E-03	-5.3365E-03	5.5231E-03	-75.1	-1.2794E-03	1.4832E-03	1.9587E-03	130.8
18	6.8963E-01	7.4986E-02	6.9370E-01	6.2	1.0704E-03	-7.1434E-03	7.2231E-03	-81.5	1.2601E-03	-8.9955E-03	9.0834E-03	-82.0
19	9.4663E-01	4.4070E-02	9.4765E-01	2.7	2.1145E-03	-8.2755E-03	8.5414E-03	-75.7	1.1864E-04	-1.4142E-03	1.4192E-03	-85.2
20	9.0451E-01	4.0594E-02	9.0542E-01	2.6	1.9081E-03	-9.5172E-03	9.7066E-03	-78.7	5.3594E-04	-4.2206E-03	4.2545E-03	-82.8
21	9.3748E-01	8.5816E-03	9.3752E-01	0.5	-3.0680E-04	9.1436E-05	3.2013E-04	163.4	-7.5460E-05	-1.3375E-03	1.3396E-03	-93.2
22	8.9474E-01	1.2899E-02	8.9483E-01	0.8	-3.6732E-04	3.6572E-04	5.1834E-04	135.1	-1.7128E-04	-4.2005E-03	4.2040E-03	-92.3
23	8.1120E-01	2.0307E-02	8.1145E-01	1.4	-4.5715E-04	8.6766E-04	9.8072E-04	117.8	-1.6791E-04	-7.3131E-03	7.3150E-03	-91.3
24	6.8940E-01	3.1864E-02	6.9014E-01	2.6	-2.1228E-04	3.7248E-04	4.2873E-04	119.7	-1.0096E-03	-7.3151E-03	7.3844E-03	-97.9
25	5.3300E-01	6.0425E-02	5.3642E-01	6.5	-9.6061E-05	-2.1082E-03	2.1104E-03	-92.6	4.2435E-03	-2.6273E-02	2.6613E-02	-80.8
26	9.3803E-01	1.3428E-02	9.3812E-01	0.8	-8.6963E-04	7.5462E-05	8.7290E-04	175.0	-1.3664E-04	-1.0521E-03	1.0609E-03	-97.4
27	8.9510E-01	1.8048E-02	8.9528E-01	1.2	-1.1132E-03	1.0702E-03	1.5443E-03	136.1	-4.1231E-04	-3.2365E-03	3.2627E-03	-97.3
28	8.1125E-01	2.6662E-02	8.1169E-01	1.9	-1.5513E-03	3.2551E-03	3.6058E-03	115.5	-5.0171E-04	-6.0897E-03	6.1103E-03	-94.7
29	6.8987E-01	3.8951E-02	6.9097E-01	3.2	-1.0155E-03	3.2230E-03	3.3792E-03	107.5	5.0111E-04	-1.1937E-02	1.1947E-02	-87.6
30	5.3470E-01	5.7140E-02	5.3775E-01	6.1	1.3627E-03	-1.0533E-02	1.0620E-02	-82.6	4.2697E-03	-3.0793E-02	3.1087E-02	-82.1
31	9.3903E-01	2.2237E-02	9.3929E-01	1.4	-1.4216E-03	2.4220E-05	1.4218E-03	179.0	-2.1247E-04	-5.0675E-04	5.4949E-04	-112.7
32	8.9578E-01	2.8390E-02	8.9623E-01	1.8	-1.7337E-03	1.2960E-03	2.1646E-03	143.2	-8.4194E-04	-9.2780E-04	1.2529E-03	-132.2
33	8.1189E-01	4.0055E-02	8.1288E-01	2.8	-2.3899E-03	4.5324E-03	5.1238E-03	117.8	-9.9691E-04	-3.2202E-03	3.3710E-03	-107.2
34	6.8946E-01	5.8549E-02	6.9194E-01	4.9	-6.8196E-04	-3.2049E-03	3.2766E-03	-102.0	4.0784E-03	-2.4254E-02	2.4595E-02	-80.5
35	9.3839E-01	3.9178E-02	9.3920E-01	2.4	-3.3823E-03	4.9763E-03	6.0170E-03	124.2	2.0831E-04	-1.3192E-03	1.3355E-03	-81.0
36	8.9607E-01	4.6013E-02	8.9725E-01	2.9	-1.2175E-03	-1.5943E-03	2.0060E-03	-127.4	2.4504E-04	-1.7128E-03	1.7303E-03	-81.9

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

37	8.1114E-01	6.5704E-02	8.1380E-01	4.6	3.2897E-03	-1.7830E-02	1.8131E-02	-79.5	9.5622E-04	-1.1339E-02	1.1379E-02	-85.2
38	9.3496E-01	8.7210E-02	9.3901E-01	5.3	5.8597E-03	-2.6326E-02	2.6970E-02	-77.5	3.2528E-04	-4.6732E-03	4.6845E-03	-86.0
39	8.9438E-01	7.8341E-02	8.9780E-01	5.0	5.5362E-03	-3.1169E-02	3.1657E-02	-79.9	3.4278E-03	-1.9721E-02	2.0017E-02	-80.1
40	9.3848E-01	1.2073E-02	9.3856E-01	0.7	-4.6100E-04	-3.5678E-06	4.6102E-04	-179.6	-6.4397E-05	-2.3440E-03	2.3449E-03	-91.6
41	8.9554E-01	1.6494E-02	8.9569E-01	1.1	-4.5991E-04	2.3513E-05	4.6051E-04	177.1	-2.7670E-04	-6.8489E-03	6.8545E-03	-92.3
42	8.1342E-01	2.4023E-02	8.1377E-01	1.7	-7.5617E-04	1.2828E-03	1.4890E-03	120.5	3.3290E-04	-1.4919E-02	1.4923E-02	-88.7
43	6.9624E-01	1.6948E-02	6.9644E-01	1.4	-1.4826E-03	3.9735E-03	4.2411E-03	110.5	3.4532E-03	-2.5195E-02	2.5431E-02	-82.2
44	9.3881E-01	1.7205E-02	9.3897E-01	1.0	-1.4254E-03	1.1238E-05	1.4255E-03	179.5	-7.2693E-05	-2.2949E-03	2.2961E-03	-91.8
45	8.9611E-01	2.0119E-02	8.9634E-01	1.3	-1.6326E-03	1.2949E-03	2.0838E-03	141.6	-4.8081E-04	-5.6544E-03	5.6748E-03	-94.9
46	8.1370E-01	2.8210E-02	8.1419E-01	2.0	-2.0882E-03	4.6239E-03	5.0735E-03	114.3	5.3399E-05	-1.1514E-02	1.1514E-02	-89.7
47	6.9403E-01	3.7153E-02	6.9503E-01	3.1	-7.0789E-04	-3.2127E-03	3.2897E-03	-102.4	3.8910E-03	-3.2230E-02	3.2464E-02	-83.1
48	9.4193E-01	2.5841E-02	9.4228E-01	1.6	-1.4812E-03	-4.4532E-03	4.6931E-03	-108.4	-4.8831E-04	-6.0437E-04	7.7698E-04	-128.9
49	8.9862E-01	2.9846E-02	8.9912E-01	1.9	-1.9732E-03	3.6022E-04	2.0058E-03	169.7	-8.7798E-04	-2.1130E-03	2.2881E-03	-112.6
50	8.1537E-01	4.2035E-02	8.1645E-01	3.0	2.1561E-04	-8.9368E-03	8.9394E-03	-88.6	2.4411E-03	-2.0309E-02	2.0456E-02	-83.1
51	9.4946E-01	1.3050E-02	9.4955E-01	0.8	1.1241E-03	-1.2583E-02	1.2633E-02	-84.9	-1.2612E-03	3.1313E-03	3.3757E-03	111.9
52	9.0245E-01	4.1097E-02	9.0338E-01	2.6	2.2484E-03	-2.1188E-02	2.1307E-02	-83.9	1.2674E-03	-1.0356E-02	1.0434E-02	-83.0
53	9.4014E-01	1.8315E-02	9.4032E-01	1.1	-2.9747E-04	-1.3883E-03	1.4198E-03	-102.1	2.9343E-04	-4.5653E-03	4.5747E-03	-86.3
54	8.9692E-01	2.0283E-02	8.9715E-01	1.3	1.0853E-04	-2.9288E-03	2.9308E-03	-87.9	-1.1989E-03	-4.9973E-03	5.1391E-03	-103.5
55	8.0938E-01	5.5664E-02	8.1129E-01	3.9	9.3638E-04	-5.5662E-03	5.6444E-03	-80.5	7.7447E-04	-2.5997E-02	2.6009E-02	-88.3
56	6.9258E-01	2.8641E-02	6.9318E-01	2.4	9.9199E-04	-7.2394E-03	7.3070E-03	-82.2	1.0304E-02	-6.6411E-02	6.7205E-02	-81.2
57	9.3992E-01	2.1185E-02	9.4016E-01	1.3	-3.0554E-03	5.0849E-03	5.9322E-03	121.0	7.3816E-04	-6.2080E-03	6.2517E-03	-83.2
58	8.9890E-01	1.7669E-02	8.9908E-01	1.1	-9.7116E-04	-1.6749E-03	1.9361E-03	-120.1	8.6705E-04	-1.1385E-02	1.1418E-02	-85.6
59	8.1631E-01	2.7562E-02	8.1678E-01	1.9	2.6172E-03	-1.8239E-02	1.8426E-02	-81.8	4.2884E-03	-3.3203E-02	3.3479E-02	-82.6
60	9.3690E-01	6.3031E-02	9.3901E-01	3.8	-1.1375E-03	-1.3337E-02	1.3385E-02	-94.9	1.6144E-03	-9.3410E-03	9.4795E-03	-80.2
61	9.0135E-01	2.9118E-02	9.0182E-01	1.9	2.3294E-03	-2.1267E-02	2.1394E-02	-83.7	4.8749E-03	-2.8456E-02	2.8871E-02	-80.3
62	9.4403E-01	3.4246E-02	9.4465E-01	2.1	1.0676E-02	-6.3999E-02	6.4883E-02	-80.5	1.9568E-03	-1.0826E-02	1.1001E-02	-79.8
63	9.3839E-01	4.8472E-02	9.3964E-01	3.0	7.1187E-04	-8.8588E-03	8.8874E-03	-85.4	1.4389E-03	-1.2464E-02	1.2547E-02	-83.4
64	9.0224E-01	1.9604E-02	9.0245E-01	1.2	8.9712E-04	-9.8817E-03	9.9224E-03	-84.8	6.2307E-03	-3.6215E-02	3.6747E-02	-80.2
65	9.4635E-01	1.8349E-02	9.4653E-01	1.1	4.0939E-03	-2.7214E-02	2.7520E-02	-81.4	1.6266E-03	-1.3538E-02	1.3635E-02	-83.1
66	9.0703E-01	-2.9242E-03	9.0704E-01	-0.2	4.4969E-03	-3.1660E-02	3.1977E-02	-81.9	6.6222E-03	-4.0509E-02	4.1046E-02	-80.7

THE INCIDENT FIELD IS OF THE FORM SINKZ
FREQUENCY = 1000.00000 MHZ. (NX = 5 NY = 5 NZ = 5)
FIELD COMPONENTS= X,Y,Z. QUADRANTS USED = 1 2 3 4 5 6 7 8
NUMBER OF PARTITIONS PER EDGE IN INTEGRATION = 1
INCIDENT ELECTRIC FIELD HAS THE FOLLOWING COMPONENTS

	E INCIDENT X-DIRECTION		E INCIDENT Y-DIRECTION		EINCIDENT Z-DIRECTION	
N	REAL	IMAG	REAL	IMAG	REAL	IMAG
1	0.0	1.0461E-01	0.0	0.0	0.0	0.0
2	0.0	3.0926E-01	0.0	0.0	0.0	0.0
3	0.0	5.0037E-01	0.0	0.0	0.0	0.0
4	0.0	6.6958E-01	0.0	0.0	0.0	0.0
5	0.0	8.0947E-01	0.0	0.0	0.0	0.0
6	0.0	1.0461E-01	0.0	0.0	0.0	0.0
7	0.0	3.0926E-01	0.0	0.0	0.0	0.0
8	0.0	5.0037E-01	0.0	0.0	0.0	0.0
9	0.0	6.6958E-01	0.0	0.0	0.0	0.0
10	0.0	8.0947E-01	0.0	0.0	0.0	0.0
11	0.0	1.0461E-01	0.0	0.0	0.0	0.0
12	0.0	3.0926E-01	0.0	0.0	0.0	0.0
13	0.0	5.0037E-01	0.0	0.0	0.0	0.0
14	0.0	6.6958E-01	0.0	0.0	0.0	0.0
15	0.0	1.0461E-01	0.0	0.0	0.0	0.0
16	0.0	3.0926E-01	0.0	0.0	0.0	0.0
17	0.0	5.0037E-01	0.0	0.0	0.0	0.0
18	0.0	6.6958E-01	0.0	0.0	0.0	0.0
19	0.0	1.0461E-01	0.0	0.0	0.0	0.0
20	0.0	3.0926E-01	0.0	0.0	0.0	0.0

21	0.0	1.0461E-01	0.0	0.0	0.0	0.0
22	0.0	3.0926E-01	0.0	0.0	0.0	0.0
23	0.0	5.0037E-01	0.0	0.0	0.0	0.0
24	0.0	6.6958E-01	0.0	0.0	0.0	0.0
25	0.0	8.0947E-01	0.0	0.0	0.0	0.0
26	0.0	1.0461E-01	0.0	0.0	0.0	0.0
27	0.0	3.0926E-01	0.0	0.0	0.0	0.0
28	0.0	5.0037E-01	0.0	0.0	0.0	0.0
29	0.0	6.6958E-01	0.0	0.0	0.0	0.0
30	0.0	8.0947E-01	0.0	0.0	0.0	0.0
31	0.0	1.0461E-01	0.0	0.0	0.0	0.0
32	0.0	3.0926E-01	0.0	0.0	0.0	0.0
33	0.0	5.0037E-01	0.0	0.0	0.0	0.0
34	0.0	6.6958E-01	0.0	0.0	0.0	0.0
35	0.0	1.0461E-01	0.0	0.0	0.0	0.0
36	0.0	3.0926E-01	0.0	0.0	0.0	0.0
37	0.0	5.0037E-01	0.0	0.0	0.0	0.0
38	0.0	1.0461E-01	0.0	0.0	0.0	0.0
39	0.0	3.0926E-01	0.0	0.0	0.0	0.0
40	0.0	1.0461E-01	0.0	0.0	0.0	0.0
41	0.0	3.0926E-01	0.0	0.0	0.0	0.0
42	0.0	5.0037E-01	0.0	0.0	0.0	0.0
43	0.0	6.6958E-01	0.0	0.0	0.0	0.0
44	0.0	1.0461E-01	0.0	0.0	0.0	0.0
45	0.0	3.0926E-01	0.0	0.0	0.0	0.0
46	0.0	5.0037E-01	0.0	0.0	0.0	0.0
47	0.0	6.6958E-01	0.0	0.0	0.0	0.0
48	0.0	1.0461E-01	0.0	0.0	0.0	0.0
49	0.0	3.0926E-01	0.0	0.0	0.0	0.0
50	0.0	5.0037E-01	0.0	0.0	0.0	0.0
51	0.0	1.0461E-01	0.0	0.0	0.0	0.0
52	0.0	3.0926E-01	0.0	0.0	0.0	0.0
53	0.0	1.0461E-01	0.0	0.0	0.0	0.0
54	0.0	3.0926E-01	0.0	0.0	0.0	0.0
55	0.0	5.0037E-01	0.0	0.0	0.0	0.0
56	0.0	6.6958E-01	0.0	0.0	0.0	0.0
57	0.0	1.0461E-01	0.0	0.0	0.0	0.0
58	0.0	3.0926E-01	0.0	0.0	0.0	0.0
59	0.0	5.0037E-01	0.0	0.0	0.0	0.0
60	0.0	1.0461E-01	0.0	0.0	0.0	0.0
61	0.0	3.0926E-01	0.0	0.0	0.0	0.0
62	0.0	1.0461E-01	0.0	0.0	0.0	0.0
63	0.0	1.0461E-01	0.0	0.0	0.0	0.0
64	0.0	3.0926E-01	0.0	0.0	0.0	0.0
65	0.0	1.0461E-01	0.0	0.0	0.0	0.0
66	0.0	3.0926E-01	0.0	0.0	0.0	0.0

(INDUCED ELECTRIC FIELDS IN QUADRANT 1)

N	EX (V/M)	EY (V/M)	EZ (V/M)	PWR DEN (W/CU. MET.)
1	1.03373E-01	3.32363E-05	6.80079E-03	8.38454E-05
2	3.05534E-01	1.22684E-04	6.72298E-03	7.29658E-04
3	4.94166E-01	1.83889E-04	6.47692E-03	1.90814E-03
4	6.61299E-01	1.62400E-04	4.95781E-03	3.41673E-03
5	8.02568E-01	8.36252E-04	2.43417E-03	5.03221E-03
6	1.03327E-01	7.94994E-05	6.93016E-03	8.37848E-05
7	3.05378E-01	3.37337E-04	6.94730E-03	7.28935E-04
8	4.93951E-01	7.35627E-04	6.48946E-03	1.90649E-03
9	6.61615E-01	2.73531E-04	3.67754E-03	3.41990E-03

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10	8.03081E-01	2.58800E-03	3.35822E-03	5.03872E-03
11	1.03276E-01	2.72338E-05	7.08022E-03	8.37189E-05
12	3.05170E-01	1.86988E-04	7.38645E-03	7.27993E-04
13	4.93458E-01	1.48620E-03	7.69098E-03	1.90283E-03
14	6.61684E-01	4.10392E-03	1.63471E-03	3.42067E-03
15	1.03337E-01	2.42536E-04	6.88374E-03	8.37971E-05
16	3.05467E-01	1.22865E-03	7.05507E-03	7.29388E-04
17	4.93971E-01	3.24238E-03	1.04675E-02	1.90725E-03
18	6.60328E-01	5.04280E-03	1.25865E-03	3.40672E-03
19	1.03787E-01	8.78205E-04	5.74748E-03	8.44177E-05
20	3.06766E-01	3.05535E-03	4.55004E-03	7.35431E-04
21	1.03413E-01	7.98179E-05	2.00460E-02	8.66875E-05
22	3.05676E-01	3.38831E-04	1.97495E-02	7.33031E-04
23	4.94269E-01	7.38849E-04	1.93648E-02	1.91154E-03
24	6.59206E-01	2.26715E-04	2.28478E-02	3.39902E-03
25	7.95170E-01	2.62089E-03	8.23875E-03	4.94039E-03
26	1.03367E-01	2.09191E-04	2.03768E-02	8.67191E-05
27	3.05467E-01	9.81221E-04	2.05045E-02	7.32277E-04
28	4.93861E-01	2.76346E-03	2.03318E-02	1.90874E-03
29	6.59834E-01	1.88209E-03	1.72796E-02	3.40377E-03
30	7.96580E-01	1.40475E-02	1.19165E-02	4.95999E-03
31	1.03263E-01	1.77758E-04	2.08567E-02	8.67049E-05
32	3.05112E-01	1.11888E-03	2.20878E-02	7.31115E-04
33	4.93658E-01	3.34082E-03	2.31515E-02	1.90817E-03
34	6.60495E-01	3.07111E-03	3.92696E-03	3.40843E-03
35	1.03042E-01	3.71495E-04	2.10777E-02	8.64222E-05
36	3.04728E-01	1.58193E-03	2.22673E-02	7.29354E-04
37	4.94004E-01	1.11623E-02	1.72132E-02	1.90985E-03
38	1.02926E-01	2.74438E-03	1.97850E-02	8.58807E-05
39	3.04927E-01	9.83459E-03	1.19882E-02	7.28288E-04
40	1.03482E-01	2.92927E-05	3.23420E-02	9.18316E-05
41	3.05782E-01	1.94506E-04	3.18794E-02	7.38427E-04
42	4.96120E-01	1.51759E-03	2.81695E-02	1.92914E-03
43	6.67951E-01	4.15424E-03	2.06864E-02	3.48909E-03
44	1.03493E-01	1.85195E-04	3.25382E-02	9.19493E-05
45	3.05794E-01	1.13191E-03	3.28896E-02	7.39009E-04
46	4.95605E-01	3.39028E-03	3.17048E-02	1.92688E-03
47	6.65566E-01	3.05016E-03	1.37810E-02	3.46233E-03
48	1.03605E-01	1.91129E-04	3.30372E-02	9.23863E-05
49	3.06159E-01	5.95368E-04	3.46647E-02	7.41682E-04
50	4.96855E-01	5.85658E-03	2.48299E-02	1.93372E-03
51	1.03755E-01	1.25132E-03	3.27529E-02	9.24948E-05
52	3.07304E-01	7.29049E-03	2.80187E-02	7.44326E-04
53	1.03702E-01	2.45270E-04	4.30318E-02	9.84837E-05
54	3.05491E-01	1.25782E-03	4.60493E-02	7.45676E-04
55	4.94041E-01	3.30201E-03	3.34901E-02	1.91570E-03
56	6.65193E-01	5.06010E-03	8.84358E-03	3.45770E-03
57	1.03835E-01	3.77971E-04	4.24913E-02	9.83384E-05
58	3.06823E-01	1.57639E-03	4.25882E-02	7.49663E-04
59	4.97765E-01	1.12319E-02	2.75966E-02	1.94264E-03
60	1.03978E-01	1.31400E-03	4.23936E-02	9.85179E-05
61	3.08748E-01	7.34709E-03	3.40938E-02	7.54230E-04
62	1.04636E-01	5.73599E-03	3.48935E-02	9.53050E-05
63	1.04159E-01	8.97820E-04	5.16493E-02	1.05606E-04
64	3.10077E-01	3.08655E-03	4.13658E-02	7.64596E-04
65	1.04634E-01	2.74666E-03	4.79286E-02	1.03538E-04
66	3.10744E-01	9.81730E-03	3.56886E-02	7.65093E-04

TOTAL POWER ABSORBED IN THE FIRST OCTANT = 9.50342E-08 WATTS

N	EXREAL	EXIMAG	EX-ABS	THETA-X	EYREAL	EYIMAG	EY-ABS	THETA-Y	EZREAL	EZIMAG	EZ-ABS	THETA-Z
1	6.1214E-04	-1.0337E-01	1.0337E-01	-89.7	3.1406E-05	1.0878E-05	3.3236E-05	19.1	6.7698E-03	6.4904E-04	6.8008E-03	5.5
2	2.7021E-03	-3.0552E-01	3.0553E-01	-89.5	1.1771E-04	3.4564E-05	1.2268E-04	16.4	6.6915E-03	6.4963E-04	6.7230E-03	5.5
3	7.2926E-03	-4.9411E-01	4.9417E-01	-89.2	1.8135E-04	3.0458E-05	1.8389E-04	9.5	6.4476E-03	6.1615E-04	6.4769E-03	5.5
4	1.5526E-02	-6.6112E-01	6.6130E-01	-88.7	-1.3187E-04	-9.4779E-05	1.6240E-04	-144.3	4.9541E-03	1.9256E-04	4.9578E-03	2.2
5	1.8890E-02	-8.0235E-01	8.0257E-01	-88.7	-8.2632E-04	-1.2847E-04	8.3625E-04	-171.2	-1.7418E-03	-1.7004E-03	2.4342E-03	-135.7
6	1.0252E-03	-1.0332E-01	1.0333E-01	-89.4	7.4712E-05	2.7170E-05	7.9499E-05	20.0	6.8946E-03	7.0080E-04	6.9302E-03	5.8
7	4.0604E-03	-3.0535E-01	3.0538E-01	-89.2	3.2114E-04	1.0326E-04	3.3734E-04	17.8	6.9093E-03	7.2585E-04	6.9473E-03	6.0
8	9.6766E-03	-4.9386E-01	4.9395E-01	-88.9	7.1576E-04	1.6979E-04	7.3563E-04	13.3	6.4577E-03	6.4143E-04	6.4895E-03	5.7
9	1.7167E-02	-6.6139E-01	6.6161E-01	-88.5	8.3469E-05	-2.6048E-04	2.7353E-04	-72.2	3.6716E-03	-2.0963E-04	3.6775E-03	-3.3
10	1.4808E-02	-8.0294E-01	8.0308E-01	-88.9	-2.5455E-03	-4.6735E-04	2.5880E-03	-169.6	-2.9089E-03	-1.6781E-03	3.3582E-03	-150.0
11	1.7526E-03	-1.0326E-01	1.0328E-01	-89.0	2.5198E-05	1.0333E-05	2.7234E-05	22.3	7.0388E-03	7.6470E-04	7.0802E-03	6.2
12	6.4897E-03	-3.0510E-01	3.0517E-01	-88.8	1.6912E-04	7.9771E-05	1.8699E-04	25.3	7.3371E-03	8.5201E-04	7.3865E-03	6.6
13	1.4777E-02	-4.9324E-01	4.9346E-01	-88.3	1.4020E-03	4.9300E-04	1.4862E-03	19.4	7.6182E-03	1.0558E-03	7.6910E-03	7.9
14	2.1342E-02	-6.6134E-01	6.6168E-01	-88.2	3.9782E-03	1.0082E-03	4.1039E-03	14.2	1.3227E-03	-9.6054E-04	1.6347E-03	-36.0
15	2.5403E-03	-1.0331E-01	1.0334E-01	-88.6	-2.2807E-04	-8.2508E-05	2.4254E-04	-160.1	6.8446E-03	7.3288E-04	6.8837E-03	6.1
16	8.4264E-03	-3.0535E-01	3.0547E-01	-88.4	-1.1710E-03	-3.7206E-04	1.2287E-03	-162.4	7.0257E-03	6.4301E-04	7.0551E-03	5.2
17	1.7910E-02	-4.9365E-01	4.9397E-01	-87.9	-3.0248E-03	-1.1679E-03	3.2424E-03	-158.9	1.0343E-02	1.6075E-03	1.0468E-02	8.8
18	4.5540E-02	-6.5876E-01	6.6033E-01	-86.0	-4.8672E-03	-1.3190E-03	5.0428E-03	-164.8	-5.4553E-04	-1.1343E-03	1.2587E-03	-115.7
19	2.3659E-03	-1.0376E-01	1.0379E-01	-88.7	-8.2785E-04	-2.9309E-04	8.7820E-04	-160.5	5.7297E-03	4.5132E-04	5.7475E-03	4.5
20	4.8519E-03	-3.0673E-01	3.0677E-01	-89.1	-2.9508E-03	-7.9235E-04	3.0554E-03	-165.0	4.5193E-03	5.2806E-04	4.5500E-03	6.7
21	5.6960E-04	-1.0341E-01	1.0341E-01	-89.7	7.4381E-05	2.8955E-05	7.9818E-05	21.3	1.9951E-02	1.9456E-03	2.0046E-02	5.6
22	2.5301E-03	-3.0567E-01	3.0568E-01	-89.5	3.2163E-04	1.0657E-04	3.3883E-04	18.3	1.9655E-02	1.9298E-03	1.9750E-02	5.6
23	6.4507E-03	-4.9423E-01	4.9427E-01	-89.3	7.2017E-04	1.6510E-04	7.3885E-04	12.9	1.9264E-02	1.9716E-03	1.9365E-02	5.8
24	1.7696E-02	-6.5897E-01	6.5921E-01	-88.5	4.5785E-05	-2.2204E-04	2.2671E-04	-78.3	2.2639E-02	3.0809E-03	2.2848E-02	7.7
25	5.6210E-02	-7.9318E-01	7.9517E-01	-85.9	-2.5981E-03	-3.4460E-04	2.6209E-03	-172.4	-6.2500E-03	-5.3679E-03	8.2387E-03	-139.3
26	9.0813E-04	-1.0336E-01	1.0337E-01	-89.5	1.9315E-04	8.0339E-05	2.0919E-04	22.6	2.0269E-02	2.0977E-03	2.0377E-02	5.9
27	3.7305E-03	-3.0544E-01	3.0547E-01	-89.3	9.2309E-04	3.3270E-04	9.8122E-04	19.8	2.0388E-02	2.1860E-03	2.0505E-02	6.1
28	9.4750E-03	-4.9377E-01	4.9386E-01	-88.9	2.6763E-03	6.8855E-04	2.7635E-03	14.4	2.0209E-02	2.2316E-03	2.0332E-02	6.3
29	2.2052E-02	-6.5947E-01	6.5983E-01	-88.1	1.8405E-03	-3.9351E-04	1.8821E-03	-12.1	1.7233E-02	1.2651E-03	1.7280E-02	4.2
30	4.9046E-02	-7.9507E-01	7.9658E-01	-86.5	-1.3715E-02	-3.0364E-03	1.4047E-02	-167.5	-1.0643E-02	-5.3607E-03	1.1916E-02	-153.3
31	1.5765E-03	-1.0325E-01	1.0326E-01	-89.1	1.6178E-04	7.3663E-05	1.7776E-04	24.5	2.0726E-02	2.3332E-03	2.0857E-02	6.4
32	6.1934E-03	-3.0505E-01	3.0511E-01	-88.8	1.0451E-03	3.9955E-04	1.1189E-03	20.9	2.1929E-02	2.6459E-03	2.2088E-02	6.9
33	1.5210E-02	-4.9342E-01	4.9366E-01	-88.2	3.2523E-03	7.6386E-04	3.3408E-03	13.2	2.2973E-02	2.8724E-03	2.3151E-02	7.1
34	3.4641E-02	-6.5959E-01	6.6050E-01	-87.0	-2.9223E-03	-9.4455E-04	3.0711E-03	-162.1	2.9792E-03	-2.5584E-03	3.9270E-03	-40.7
35	2.9448E-03	-1.0300E-01	1.0304E-01	-88.4	3.7128E-04	1.2599E-05	3.7149E-04	1.9	2.0932E-02	2.4754E-03	2.1078E-02	6.7
36	1.0481E-02	-3.0455E-01	3.0473E-01	-88.0	-1.4395E-03	-6.5606E-04	1.5819E-03	-155.5	2.2118E-02	2.5766E-03	2.2267E-02	6.6
37	2.4072E-02	-4.9342E-01	4.9400E-01	-87.2	-1.0687E-02	-3.2220E-03	1.1162E-02	-163.2	1.7145E-02	1.5346E-03	1.7213E-02	5.1
38	7.3183E-03	-1.0267E-01	1.0293E-01	-85.9	-2.5987E-03	-8.8220E-04	2.7444E-03	-161.2	1.9683E-02	2.0051E-03	1.9785E-02	5.8
39	1.7049E-02	-3.0445E-01	3.0493E-01	-86.8	-9.5128E-03	-2.4952E-03	9.8346E-03	-165.3	1.1940E-02	1.0772E-03	1.1988E-02	5.2
40	5.3008E-04	-1.0348E-01	1.0348E-01	-89.7	2.2722E-05	1.8487E-05	2.9293E-05	39.1	3.2178E-02	3.2535E-03	3.2342E-02	5.8
41	2.9103E-03	-3.0577E-01	3.0578E-01	-89.5	1.6234E-04	1.0714E-04	1.9451E-04	33.4	3.1715E-02	3.2292E-03	3.1879E-02	5.8
42	6.5631E-03	-4.9608E-01	4.9612E-01	-89.2	1.4370E-03	4.8797E-04	1.5176E-03	18.8	2.8038E-02	2.7141E-03	2.8170E-02	5.5
43	-5.6346E-03	-6.6793E-01	6.6795E-01	-90.5	4.0886E-03	7.3563E-04	4.1542E-03	10.2	2.0653E-02	1.1814E-03	2.0686E-02	3.3
44	6.6925E-04	-1.0349E-01	1.0349E-01	-89.6	1.5581E-04	1.0010E-04	1.8520E-04	32.7	3.2354E-02	3.4561E-03	3.2538E-02	6.1
45	3.0112E-03	-3.0578E-01	3.0579E-01	-89.4	1.0337E-03	4.6110E-04	1.1319E-03	24.0	3.2692E-02	3.6028E-03	3.2890E-02	6.3
46	[illegible].2350E-03	-4.9554E-01	4.9560E-01	-89.0	3.3020E-03	7.6882E-04	3.3903E-03	13.1	3.1544E-02	3.1902E-03	3.1705E-02	5.8
47	1.4137E-02	-6.6542E-01	6.6557E-01	-88.8	-2.7311E-03	-1.3582E-03	3.0502E-03	-153.6	1.3747E-02	-9.7472E-04	1.3781E-02	-4.1
48	1.1383E-03	-1.0360E-01	1.0360E-01	-89.4	9.3664E-05	1.6661E-04	1.9113E-04	60.7	3.2817E-02	3.8114E-03	3.3037E-02	6.6
49	4.5494E-03	-3.0613E-01	3.0616E-01	-89.1	5.5641E-04	2.1182E-04	5.9537E-04	20.8	3.4420E-02	4.1118E-03	3.4665E-02	6.8
50	1.1474E-02	-4.9672E-01	4.9686E-01	-88.7	-5.6032E-03	-1.7040E-03	5.8566E-03	-163.1	2.4772E-02	1.7002E-03	2.4830E-02	3.9
51	1.2476E-04	-1.0375E-01	1.0375E-01	-89.9	-1.1093E-03	-5.7896E-04	1.2513E-03	-152.4	3.2521E-02	3.8882E-03	3.2753E-02	6.8
52	5.3326E-03	-3.0726E-01	3.0730E-01	-89.0	-6.9401E-03	-2.2329E-03	7.2905E-03	-162.2	2.7829E-02	3.2565E-03	2.8019E-02	6.7
53	3.6738E-04	-1.0370E-01	1.0370E-01	-89.8	-2.3463E-04	-7.1459E-05	2.4527E-04	-163.1	4.2793E-02	4.5246E-03	4.3032E-02	6.0
54	3.1585E-03	-3.0547E-01	3.0549E-01	-89.4	-1.2203E-03	-3.0496E-04	1.2578E-03	-166.0	4.5726E-02	5.4463E-03	4.6049E-02	6.8
55	2.5934E-02	-4.9336E-01	4.9404E-01	-87.0	-3.2491E-03	-5.8867E-04	3.3020E-03	-169.7	3.3419E-02	2.1884E-03	3.3490E-02	3.7
56	1.2231E-02	-6.6508E-01	6.6519E-01	-88.9	-4.9294E-03	-1.1426E-03	5.0601E-03	-166.9	-6.5665E-03	-5.9237E-03	8.8436E-03	-137.9

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

57	4.0892E-04	-1.0383E-01	1.0383E-01	-89.8	3.7548E-04	4.3349E-05	3.7797E-04	6.6	4.2241E-02	4.6063E-03	4.2491E-02	6.2
58	7.8959E-04	-3.0682E-01	3.0682E-01	-89.9	-1.5002E-03	-4.8424E-04	1.5764E-03	-162.1	4.2317E-02	4.7980E-03	4.2588E-02	6.5
59	5.1883E-03	-4.9774E-01	4.9777E-01	-89.4	-1.0932E-02	-2.5782E-03	1.1232E-02	-166.7	2.7582E-02	9.1181E-04	2.7597E-02	1.9
60	4.0223E-03	-1.0390E-01	1.0398E-01	-87.8	-1.3138E-03	-2.3369E-05	1.3140E-03	-179.0	4.2137E-02	4.6608E-03	4.2394E-02	6.3
61	4.1645E-04	-3.0875E-01	3.0875E-01	-89.9	-7.1410E-03	-1.7280E-03	7.3471E-03	-166.4	3.3899E-02	3.6390E-03	3.4094E-02	6.1
62	-1.4576E-03	-1.0463E-01	1.0464E-01	-90.8	-5.6050E-03	-1.2191E-03	5.7360E-03	-167.7	3.4575E-02	4.7042E-03	3.4893E-02	7.7
63	3.9233E-03	-1.0409E-01	1.0416E-01	-87.8	-8.7637E-04	-1.9510E-04	8.9782E-04	-167.4	5.1361E-02	5.4468E-03	5.1649E-02	6.1
64	-1.7047E-03	-3.1007E-01	3.1008E-01	-90.3	-3.0078E-03	-6.9269E-04	3.0866E-03	-167.0	4.1031E-02	5.2546E-03	4.1366E-02	7.3
65	1.0882E-03	-1.0463E-01	1.0463E-01	-89.4	-2.6224E-03	-8.1672E-04	2.7467E-03	-162.7	4.7711E-02	4.5618E-03	4.7929E-02	5.5
66	-6.9276E-03	-3.1067E-01	3.1074E-01	-91.3	-9.4192E-03	-2.7674E-03	9.8173E-03	-163.6	3.5482E-02	3.8361E-03	3.5689E-02	6.2

FIELDS IN FRONT LAYER (OCTANTS 5 6 7 8)

(INDUCED ELECTRIC FIELDS IN ONE OCTANT)

FREQUENCY = 1000.00000 MHZ. (NX = 5 NY = 5 NZ = 5)

FIELD COMPONENTS= X,Y,Z. QUADRANTS USED = 1 2 3 4 5 6 7 8

NUMBER OF PARTITIONS PER EDGE IN INTEGRATION = 1

N	EX (V/M)	EY (V/M)	EZ (V/M)	PWR DEN (W/CU. MET.)
1	9.42820E-01	1.42890E-04	6.88559E-03	6.94497E-03
2	9.46155E-01	2.66692E-04	7.05799E-03	6.99422E-03
3	9.53512E-01	3.82490E-04	7.18457E-03	7.10341E-03
4	9.65791E-01	1.35778E-04	6.38614E-03	7.28744E-03
5	9.87821E-01	9.72964E-04	7.49270E-03	7.62381E-03
6	9.43509E-01	3.88766E-04	7.02101E-03	6.95515E-03
7	9.47008E-01	7.44336E-04	7.27862E-03	7.00685E-03
8	9.54733E-01	1.37311E-03	7.19183E-03	7.12162E-03
9	9.68613E-01	7.14181E-04	5.83755E-03	7.33005E-03
10	9.90316E-01	3.08299E-03	9.10837E-03	7.66264E-03
11	9.45028E-01	4.83982E-04	7.15536E-03	6.97757E-03
12	9.49025E-01	6.41297E-04	7.68934E-03	7.03678E-03
13	9.56965E-01	2.40339E-03	8.41611E-03	7.15514E-03
14	9.73600E-01	6.35479E-03	6.31226E-03	7.40911E-03
15	9.48008E-01	1.23176E-03	6.87543E-03	7.02162E-03
16	9.53977E-01	2.83927E-03	6.98328E-03	7.11038E-03
17	9.62615E-01	6.09608E-03	1.16234E-02	7.24062E-03
18	9.76334E-01	8.31732E-03	8.06595E-03	7.44814E-03
19	9.55763E-01	8.50741E-03	5.91308E-03	7.13741E-03
20	9.64378E-01	9.98662E-03	6.19813E-03	7.26689E-03
21	9.43578E-01	3.86267E-04	2.02941E-02	6.95900E-03
22	9.47377E-01	7.36082E-04	2.07524E-02	7.01527E-03
23	9.55178E-01	1.37101E-03	2.15363E-02	7.13148E-03
24	9.63557E-01	6.48122E-04	2.58329E-02	7.25867E-03
25	9.77739E-01	3.06116E-03	2.33910E-02	7.47288E-03
26	9.44368E-01	1.06279E-03	2.06469E-02	6.97077E-03
27	9.48253E-01	2.16579E-03	2.14952E-02	7.02852E-03
28	9.55876E-01	4.94565E-03	2.23199E-02	7.14235E-03
29	9.66314E-01	4.60826E-03	2.13131E-02	7.29874E-03
30	9.80878E-01	1.68388E-02	2.94817E-02	7.52559E-03
31	9.45815E-01	1.58412E-03	2.11300E-02	6.99230E-03
32	9.50029E-01	2.91983E-03	2.30495E-02	7.05542E-03
33	9.58801E-01	6.78496E-03	2.47317E-02	7.18716E-03
34	9.71854E-01	3.18245E-03	2.17238E-02	7.38267E-03
35	9.46184E-01	6.22318E-03	2.10681E-02	6.99802E-03
36	9.52447E-01	9.64163E-04	2.22893E-02	7.09104E-03
37	9.65449E-01	2.02178E-02	2.06831E-02	7.28851E-03
38	9.46871E-01	2.68130E-02	2.04775E-02	7.01330E-03
39	9.57201E-01	3.23833E-02	2.24729E-02	7.17022E-03
40	9.45045E-01	4.84228E-04	3.27246E-02	6.98579E-03
41	9.49020E-01	6.27846E-04	3.35419E-02	7.04503E-03

42	9.59956E-01	2.33274E-03	3.28410E-02	7.20780E-03
43	9.80650E-01	6.44373E-03	3.14890E-02	7.52115E-03
44	9.45873E-01	1.58373E-03	3.29329E-02	6.99815E-03
45	9.50703E-01	2.79370E-03	3.44399E-02	7.07055E-03
46	9.60770E-01	6.62687E-03	3.47543E-02	7.22134E-03
47	9.77683E-01	2.74454E-03	3.27723E-02	7.47614E-03
48	9.49652E-01	4.88087E-03	3.35963E-02	7.05462E-03
49	9.55115E-01	2.53394E-03	3.58426E-02	7.13700E-03
50	9.67734E-01	9.28293E-03	3.13540E-02	7.32482E-03
51	9.56495E-01	1.22102E-02	3.37909E-02	7.15761E-03
52	9.62375E-01	2.10645E-02	2.98466E-02	7.24610E-03
53	9.47661E-01	1.31835E-03	4.34610E-02	7.03087E-03
54	9.51277E-01	2.94118E-03	4.80731E-02	7.08787E-03
55	9.56666E-01	6.50338E-03	4.31286E-02	7.16494E-03
56	9.71664E-01	8.49902E-03	6.27956E-02	7.40739E-03
57	9.47795E-01	6.09820E-03	4.28886E-02	7.03275E-03
58	9.54935E-01	1.30290E-03	4.44973E-02	7.13971E-03
59	9.66366E-01	2.07085E-02	4.13084E-02	7.31249E-03
60	9.47692E-01	1.33144E-02	4.28731E-02	7.03230E-03
61	9.62206E-01	2.17130E-02	4.32724E-02	7.25143E-03
62	9.55632E-01	6.48564E-02	3.61266E-02	7.17768E-03
63	9.46839E-01	8.80810E-03	5.30383E-02	7.02652E-03
64	9.62186E-01	9.98434E-03	5.41367E-02	7.25650E-03
65	9.53230E-01	2.72385E-02	4.95114E-02	7.12375E-03
66	9.64381E-01	3.20689E-02	5.29088E-02	7.29577E-03

TOTAL POWER ABSORBED IN THE FIRST OCTANT = 4.73599E-07 WATTS

N	EXREAL	EXIMAG	EX-ABS	THETA-X	EYREAL	EYIMAG	EY-ABS	THETA-Y	EZREAL	EZIMAG	EZ-ABS	THETA-Z
1	-9.3634E-01	-1.1031E-01	9.4282E-01	-173.3	1.3837E-04	-3.5664E-05	1.4289E-04	-14.5	6.7992E-03	1.0871E-03	6.8856E-03	9.1
2	-8.9149E-01	-3.1694E-01	9.4616E-01	-160.4	2.4491E-04	-1.0556E-04	2.6669E-04	-23.3	6.7635E-03	2.0177E-03	7.0580E-03	16.6
3	-8.0330E-01	-5.1370E-01	9.5351E-01	-147.4	3.1699E-04	-2.1404E-04	3.8249E-04	-34.0	6.5092E-03	3.0412E-03	7.1846E-03	25.0
4	-6.7452E-01	-6.9121E-01	9.6579E-01	-134.3	-9.5988E-05	-9.6032E-05	1.3578E-04	-135.0	4.7536E-03	4.2646E-03	6.3861E-03	41.9
5	-5.2115E-01	-8.3916E-01	9.8782E-01	-121.8	-8.1841E-04	5.2618E-04	9.7296E-04	147.3	-3.4091E-03	6.6722E-03	7.4927E-03	117.1
6	-9.3644E-01	-1.1530E-01	9.4351E-01	-173.0	3.8324E-04	-6.5325E-05	3.8877E-04	-9.7	6.9428E-03	1.0450E-03	7.0210E-03	8.6
7	-8.9053E-01	-3.2214E-01	9.4701E-01	-160.1	6.9698E-04	-2.6126E-04	7.4434E-04	-20.5	7.0477E-03	1.8187E-03	7.2786E-03	14.5
8	-8.0118E-01	-5.1925E-01	9.5473E-01	-147.1	1.1851E-03	-6.9351E-04	1.3731E-03	-30.3	6.5586E-03	2.9508E-03	7.1918E-03	24.2
9	-6.7354E-01	-6.9610E-01	9.6861E-01	-134.1	1.4601E-04	-6.9910E-04	7.1418E-04	-78.2	3.0626E-03	4.9696E-03	5.8376E-03	58.4
10	-5.2622E-01	-8.3894E-01	9.9032E-01	-122.1	-2.6345E-03	1.6013E-03	3.0830E-03	148.7	-4.4748E-03	7.9334E-03	9.1084E-03	119.4
11	-9.3671E-01	-1.2508E-01	9.4503E-01	-172.4	4.8396E-04	4.4561E-06	4.8398E-04	0.5	7.0821E-03	1.0212E-03	7.1554E-03	8.2
12	-8.8900E-01	-3.3215E-01	9.4902E-01	-159.5	6.3980E-04	4.3829E-05	6.4130E-04	3.9	7.5472E-03	1.4716E-03	7.6893E-03	11.0
13	-7.9660E-01	-5.3029E-01	9.5696E-01	-146.3	2.2907E-03	-7.2730E-04	2.4034E-03	-17.6	8.1456E-03	2.1167E-03	8.4161E-03	14.6
14	-6.7030E-01	-7.0638E-01	9.7380E-01	-133.5	5.6516E-03	-2.9057E-03	6.3548E-03	-27.2	-3.3421E-04	6.3034E-03	6.3123E-03	93.0
15	-9.3772E-01	-1.3931E-01	9.4801E-01	-171.5	-6.4070E-05	1.2301E-03	1.2318E-03	93.0	6.7417E-03	1.3493E-03	6.8754E-03	11.3
16	-8.8946E-01	-3.4487E-01	9.5398E-01	-158.8	-1.5238E-03	2.3957E-03	2.8393E-03	122.5	6.7012E-03	1.9648E-03	6.9833E-03	16.3
17	-7.9657E-01	-5.4047E-01	9.6261E-01	-145.8	-4.4480E-03	4.1687E-03	6.0961E-03	136.9	1.1623E-02	1.2431E-04	1.1623E-02	0.6
18	-6.4409E-01	-7.3374E-01	9.7633E-01	-131.3	-5.9376E-03	5.8243E-03	8.3173E-03	135.6	-1.8056E-03	7.8612E-03	8.0659E-03	102.9
19	-9.4426E-01	-1.4783E-01	9.5576E-01	-171.1	-2.9423E-03	7.9824E-03	8.5074E-03	110.2	5.6111E-03	1.8655E-03	5.9131E-03	18.4
20	-8.9966E-01	-3.4732E-01	9.6438E-01	-158.9	-4.8589E-03	8.7249E-03	9.9866E-03	119.1	3.9833E-03	4.7487E-03	6.1981E-03	50.0
21	-9.3691E-01	-1.1199E-01	9.4358E-01	-173.2	3.8118E-04	-6.2482E-05	3.8627E-04	-9.3	2.0027E-02	3.2831E-03	2.0294E-02	9.3
22	-8.9221E-01	-3.1856E-01	9.4738E-01	-160.4	6.8896E-04	-2.5915E-04	7.3608E-04	-20.6	1.9826E-02	6.1303E-03	2.0752E-02	17.2
23	-8.0475E-01	-5.1453E-01	9.5518E-01	-147.4	1.1773E-03	-7.0256E-04	1.3710E-03	-30.8	1.9432E-02	9.2848E-03	2.1536E-02	25.5
24	-6.7171E-01	-6.9083E-01	9.6356E-01	-134.2	2.5807E-04	-5.9453E-04	6.4812E-04	-66.5	2.3649E-02	1.0396E-02	2.5833E-02	23.7
25	-4.7679E-01	-8.5361E-01	9.7774E-01	-119.2	-2.5021E-03	1.7636E-03	3.0612E-03	144.8	-1.0494E-02	2.0905E-02	2.3391E-02	116.7
26	-9.3712E-01	-1.1679E-01	9.4437E-01	-172.9	1.0628E-03	4.8777E-06	1.0628E-03	0.3	2.0405E-02	3.1499E-03	2.0647E-02	8.8
27	-8.9137E-01	-3.2349E-01	9.4825E-01	-160.1	2.0363E-03	-7.3753E-04	2.1658E-03	-19.9	2.0800E-02	5.4225E-03	2.1495E-02	14.6
28	-8.0178E-01	-5.2043E-01	9.5588E-01	-147.0	4.2276E-03	-2.5665E-03	4.9457E-03	-31.3	2.0711E-02	8.3213E-03	2.2320E-02	21.9
29	-6.6782E-01	-6.9842E-01	9.6631E-01	-133.7	2.8560E-03	-3.6165E-03	4.6083E-03	-51.7	1.6732E-02	1.3202E-02	2.1313E-02	38.3
30	-4.8566E-01	-8.5221E-01	9.8088E-01	-119.7	-1.5078E-02	7.4963E-03	1.6839E-02	153.6	-1.4912E-02	2.5432E-02	2.9482E-02	120.4

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31	-9.3745E-01	-1.2549E-01	9.4581E-01	-172.4	1.5834E-03	4.9443E-05	1.5841E-03	1.8	2.0938E-02	2.8400E-03	2.1130E-02	7.7
32	-8.8959E-01	-3.3344E-01	9.5003E-01	-159.5	2.7788E-03	-8.9646E-04	2.9198E-03	-17.9	2.2771E-02	3.5737E-03	2.3049E-02	8.9
33	-7.9668E-01	-5.3348E-01	9.5880E-01	-146.2	5.6422E-03	-3.7685E-03	6.7850E-03	-33.7	2.3970E-02	6.0926E-03	2.4732E-02	14.3
34	-6.5481E-01	-7.1814E-01	9.7185E-01	-132.4	-2.2403E-03	2.2603E-03	3.1824E-03	134.7	-1.0992E-03	2.1696E-02	2.1724E-02	92.9
35	-9.3544E-01	-1.4218E-01	9.4618E-01	-171.4	3.7536E-03	-4.9637E-03	6.2232E-03	-52.9	2.0724E-02	3.7945E-03	2.1068E-02	10.4
36	-8.8559E-01	-3.5056E-01	9.5245E-01	-158.4	-2.2196E-04	9.3827E-04	9.6416E-04	103.3	2.1873E-02	4.2894E-03	2.2289E-02	11.1
37	-7.8707E-01	-5.5912E-01	9.6545E-01	-144.6	-1.3977E-02	1.4609E-02	2.0218E-02	133.7	1.6188E-02	1.2873E-02	2.0683E-02	38.5
38	-9.2764E-01	-1.8988E-01	9.4687E-01	-168.4	-8.4584E-03	2.5444E-02	2.6813E-02	108.4	1.9358E-02	6.6783E-03	2.0477E-02	19.0
39	-8.7733E-01	-3.8279E-01	9.5720E-01	-156.4	-1.5049E-02	2.8674E-02	3.2383E-02	117.7	8.5119E-03	2.0799E-02	2.2473E-02	67.7
40	-9.3795E-01	-1.1555E-01	9.4505E-01	-173.0	4.8373E-04	2.2055E-05	4.8423E-04	2.6	3.2242E-02	5.5975E-03	3.2725E-02	9.8
41	-8.9263E-01	-3.2226E-01	9.4902E-01	-160.1	6.2225E-04	8.3624E-05	6.2785E-04	7.7	3.1992E-02	1.0078E-02	3.3542E-02	17.5
42	-8.0685E-01	-5.2010E-01	9.5996E-01	-147.2	2.1932E-03	-7.9478E-04	2.3327E-03	-19.9	2.7706E-02	1.7633E-02	3.2841E-02	32.5
43	-7.0187E-01	-6.8487E-01	9.8065E-01	-135.7	5.5711E-03	-3.2379E-03	6.4437E-03	-30.2	1.7200E-02	2.6377E-02	3.1489E-02	56.9
44	-9.3814E-01	-1.2070E-01	9.4587E-01	-172.7	1.5812E-03	8.8864E-05	1.5837E-03	3.2	3.2427E-02	5.7510E-03	3.2933E-02	10.1
45	-8.9310E-01	-3.2590E-01	9.5070E-01	-160.0	2.6664E-03	-8.3376E-04	2.7937E-03	-17.4	3.3172E-02	9.2573E-03	3.4440E-02	15.6
46	-8.0546E-01	-5.2375E-01	9.6077E-01	-147.0	5.3902E-03	-3.8551E-03	6.6269E-03	-35.6	3.1491E-02	1.4704E-02	3.4754E-02	25.0
47	-6.7990E-01	-7.0257E-01	9.7768E-01	-134.1	-2.0232E-03	1.8545E-03	2.7445E-03	137.5	9.8555E-03	3.1255E-02	3.2772E-02	72.5
48	-9.4079E-01	-1.2944E-01	9.4965E-01	-172.2	1.5748E-03	4.6198E-03	4.8809E-03	71.2	3.3305E-02	4.4158E-03	3.3596E-02	7.6
49	-8.9407E-01	-3.3597E-01	9.5512E-01	-159.4	2.5296E-03	-1.4840E-04	2.5339E-03	-3.4	3.5298E-02	6.2248E-03	3.5843E-02	10.0
50	-8.0390E-01	-5.3876E-01	9.6773E-01	-146.2	-5.8188E-03	7.2328E-03	9.2829E-03	128.8	2.2331E-02	2.2010E-02	3.1354E-02	44.6
51	-9.4934E-01	-1.1681E-01	9.5650E-01	-173.0	-2.2335E-03	1.2004E-02	1.2210E-02	100.5	3.3782E-02	7.5690E-04	3.3791E-02	1.3
52	-8.9712E-01	-3.4835E-01	9.6238E-01	-158.8	-9.1886E-03	1.8955E-02	2.1064E-02	115.9	2.6561E-02	1.3613E-02	2.9847E-02	27.1
53	-9.3977E-01	-1.2202E-01	9.4766E-01	-172.6	6.2839E-05	1.3168E-03	1.3183E-03	87.3	4.2500E-02	9.0899E-03	4.3461E-02	12.1
54	-8.9376E-01	-3.2576E-01	9.5128E-01	-160.0	-1.3288E-03	2.6239E-03	2.9412E-03	116.9	4.6925E-02	1.0444E-02	4.8073E-02	12.5
55	-7.8344E-01	-5.4902E-01	9.5667E-01	-145.0	-4.1855E-03	4.9775E-03	6.5034E-03	130.1	3.2644E-02	2.8186E-02	4.3129E-02	40.8
56	-6.8035E-01	-6.9372E-01	9.7166E-01	-134.4	-5.9214E-03	6.0968E-03	8.4990E-03	134.2	-1.6871E-02	6.0487E-02	6.2796E-02	105.6
57	-9.3951E-01	-1.2502E-01	9.4780E-01	-172.4	3.4309E-03	-5.0415E-03	6.0982E-03	-55.8	4.1503E-02	1.0814E-02	4.2889E-02	14.6
58	-8.9811E-01	-3.2449E-01	9.5494E-01	-160.1	-5.2901E-04	1.1907E-03	1.3029E-03	114.0	4.1450E-02	1.6183E-02	4.4497E-02	21.3
59	-8.1112E-01	-5.2530E-01	9.6637E-01	-147.1	-1.3549E-02	1.5661E-02	2.0708E-02	130.9	2.3293E-02	3.4115E-02	4.1308E-02	55.7
60	-9.3287E-01	-1.6693E-01	9.4769E-01	-169.9	-1.7631E-04	1.3313E-02	1.3314E-02	90.8	4.0522E-02	1.4002E-02	4.2873E-02	19.1
61	-9.0094E-01	-3.3787E-01	9.6221E-01	-159.4	-9.4704E-03	1.9539E-02	2.1713E-02	115.9	2.9024E-02	3.2095E-02	4.3272E-02	47.9
62	-9.4549E-01	-1.3887E-01	9.5563E-01	-171.6	-1.6281E-02	6.2780E-02	6.4856E-02	104.5	3.2618E-02	1.5530E-02	3.6127E-02	25.5
63	-9.3447E-01	-1.5256E-01	9.4684E-01	-170.7	-1.5882E-03	8.6637E-03	8.8081E-03	100.4	4.9922E-02	1.7911E-02	5.3038E-02	19.7
64	-9.0394E-01	-3.2968E-01	9.6219E-01	-160.0	-3.9049E-03	9.1890E-03	9.9843E-03	113.0	3.4800E-02	4.1470E-02	5.4137E-02	50.0
65	-9.4526E-01	-1.2298E-01	9.5323E-01	-172.6	-6.7163E-03	2.6397E-02	2.7238E-02	104.3	4.6084E-02	1.8100E-02	4.9511E-02	21.4
66	-9.1396E-01	-3.0774E-01	9.6438E-01	-151.4	-1.3916E-02	2.8892E-02	3.2069E-02	115.7	2.8860E-02	4.4345E-02	5.2909E-02	56.9

FIELDS IN BACK LAYER (OCTANTS 1 2 3 4)

(INDUCED ELECTRIC FIELDS IN ONE OCTANT)

FREQUENCY = 1000.00000 MHZ. (NX = 5 NY = 5 NZ = 5)

FIELD COMPONENTS= X,Y,Z. QUADRANTS USED = 1 2 3 4 5 6 7 8

NUMBER OF PARTITIONS PER EDGE IN INTEGRATION = 1

N	EX (V/M)	EY (V/M)	EZ (V/M)	PWR DEN (W/CU. MET.)
1	9.42515E-01	9.48994E-05	6.74356E-03	6.94047E-03
2	9.43884E-01	1.74944E-04	6.65844E-03	6.96064E-03
3	9.45576E-01	2.78732E-04	6.63720E-03	6.98561E-03
4	9.46583E-01	1.92069E-04	6.45133E-03	7.00048E-03
5	9.47859E-01	1.14422E-03	1.00733E-02	7.01984E-03
6	9.42923E-01	2.62657E-04	6.85574E-03	6.94649E-03
7	9.43850E-01	4.70967E-04	6.78076E-03	6.96014E-03
8	9.44845E-01	1.06207E-03	6.57192E-03	6.97482E-03
9	9.45417E-01	1.79353E-04	6.88206E-03	6.98328E-03
10	9.47184E-01	3.53059E-03	1.13692E-02	7.01015E-03
11	9.43739E-01	4.33869E-04	7.01392E-03	6.95853E-03
12	9.43868E-01	3.22999E-04	7.13088E-03	6.96046E-03
13	9.43735E-01	1.78856E-03	7.09074E-03	6.95850E-03
14	9.42430E-01	5.43496E-03	8.74761E-03	6.93968E-03
15	9.45195E-01	1.44915E-03	6.94846E-03	6.98003E-03

16	9.44491E-01	3.24470E-03	7.38152E-03	6.96974E-03
17	9.44732E-01	6.69868E-03	9.57638E-03	6.97386E-03
18	9.38756E-01	9.27512E-03	1.01550E-02	6.88634E-03
19	9.50868E-01	8.66465E-03	5.92710E-03	7.06453E-03
20	9.47509E-01	1.03622E-02	6.26022E-03	7.01500E-03
21	9.42829E-01	2.61748E-04	1.98852E-02	6.94783E-03
22	9.43826E-01	4.74499E-04	1.96156E-02	6.96244E-03
23	9.45066E-01	1.06572E-03	1.98293E-02	6.98081E-03
24	9.45120E-01	2.24396E-04	2.20401E-02	6.98232E-03
25	9.40266E-01	3.64348E-03	3.17044E-02	6.91499E-03
26	9.43232E-01	6.94192E-04	2.01590E-02	6.95386E-03
27	9.43658E-01	1.41577E-03	2.00029E-02	6.96009E-03
28	9.44344E-01	4.10097E-03	2.00814E-02	6.97035E-03
29	9.44387E-01	2.94731E-03	2.06975E-02	6.97113E-03
30	9.40904E-01	1.83496E-02	3.67108E-02	6.92957E-03
31	9.44088E-01	1.26360E-03	2.05945E-02	6.96663E-03
32	9.43454E-01	1.83005E-03	2.11567E-02	6.95747E-03
33	9.43206E-01	5.36597E-03	2.19765E-02	6.95429E-03
34	9.41042E-01	5.49619E-03	2.77261E-02	6.92467E-03
35	9.43492E-01	5.82714E-03	2.11718E-02	6.95828E-03
36	9.42693E-01	3.48194E-03	2.23794E-02	6.94673E-03
37	9.38359E-01	2.23143E-02	2.05855E-02	6.88624E-03
38	9.42401E-01	2.74031E-02	2.01856E-02	6.94748E-03
39	9.39055E-01	3.38985E-02	2.41612E-02	6.90279E-03
40	9.43453E-01	4.38536E-04	3.21264E-02	6.96199E-03
41	9.43870E-01	3.24992E-04	3.16464E-02	6.96791E-03
42	9.46150E-01	1.89710E-03	3.08852E-02	7.00123E-03
43	9.49054E-01	5.38215E-03	3.40259E-02	7.04601E-03
44	9.43434E-01	1.27449E-03	3.23023E-02	6.96181E-03
45	9.43410E-01	1.85530E-03	3.22761E-02	6.96146E-03
46	9.45498E-01	5.52759E-03	3.26753E-02	6.99270E-03
47	9.46689E-01	5.72005E-03	3.75984E-02	7.01302E-03
48	9.46266E-01	4.50558E-03	3.24869E-02	7.00386E-03
49	9.44485E-01	1.52789E-03	3.36015E-02	6.97799E-03
50	9.43616E-01	1.19269E-02	3.29672E-02	6.96594E-03
51	9.53908E-01	1.31622E-02	3.20385E-02	7.11828E-03
52	9.45995E-01	2.38858E-02	2.99499E-02	7.00292E-03
53	9.44376E-01	1.55372E-03	4.30867E-02	6.98206E-03
54	9.44180E-01	3.41957E-03	4.45295E-02	6.98024E-03
55	9.43038E-01	6.57500E-03	4.16657E-02	6.96171E-03
56	9.49643E-01	9.26071E-03	7.24308E-02	7.08713E-03
57	9.43956E-01	5.78625E-03	4.30089E-02	6.97607E-03
58	9.45016E-01	3.28168E-03	4.36836E-02	6.99199E-03
59	9.46536E-01	2.24162E-02	4.53697E-02	7.01946E-03
60	9.41806E-01	1.35830E-02	4.40006E-02	6.94624E-03
61	9.44130E-01	2.34927E-02	4.60360E-02	6.98478E-03
62	9.45196E-01	6.54145E-02	3.70411E-02	7.02380E-03
63	9.43954E-01	9.05541E-03	5.32645E-02	6.98413E-03
64	9.46221E-01	1.07830E-02	5.64995E-02	7.02065E-03
65	9.51361E-01	2.80695E-02	5.01475E-02	7.09679E-03
66	9.53169E-01	3.47771E-02	5.58358E-02	7.13170E-03

TOTAL POWER ABSORBED IN THE FIRST OCTANT = 4.60666E-07 WATTS

N	EXREAL	EXIMAG	EX-ABS	THETA-X	EYREAL	EYIMAG	EY-ABS	THETA-Y	EZREAL	EZIMAG	EZ-ABS	THETA-Z
1	9.3757E-01	-9.6436E-02	9.4252E-01	-5.9	-7.5557E-05	5.7420E-05	9.4899E-05	142.8	6.7403E-03	2.1100E-04	6.7436E-03	1.8
2	8.9690E-01	-2.9410E-01	9.4388E-01	-18.2	-9.4829E-06	1.7469E-04	1.7494E-04	93.1	6.6196E-03	-7.1840E-04	6.6584E-03	-6.2
3	8.1789E-01	-4.7452E-01	9.4558E-01	-30.1	4.5707E-05	2.7496E-04	2.7873E-04	80.6	6.3859E-03	-1.8089E-03	6.6372E-03	-15.8
4	7.0557E-01	-6.3102E-01	9.4658E-01	-41.8	-1.6776E-04	-9.3527E-05	1.9207E-04	-150.9	5.1546E-03	-3.8794E-03	6.4513E-03	-37.0

5	5.5893E-01	-7.6553E-01	9.4786E-01	-53.9	-8.3424E-04	-7.8313E-04	1.1442E-03	-136.8	-7.4451E-05	-1.0073E-02	1.0073E-02	-90.4
6	9.3849E-01	-9.1343E-02	9.4292E-01	-5.6	-2.3381E-04	1.1966E-04	2.6266E-04	152.9	6.8465E-03	3.5658E-04	6.8557E-03	3.0
7	8.9866E-01	-2.8857E-01	9.4385E-01	-17.8	-5.4693E-05	4.6778E-04	4.7097E-04	96.7	6.7708E-03	-3.6703E-04	6.7808E-03	-3.1
8	8.2053E-01	-4.6846E-01	9.4485E-01	-29.7	2.4642E-04	1.0331E-03	1.0621E-03	76.6	6.3567E-03	-1.6679E-03	6.5719E-03	-14.7
9	7.0787E-01	-6.2668E-01	9.4542E-01	-41.5	2.0926E-05	1.7813E-04	1.7935E-04	83.3	4.2805E-03	-5.3889E-03	6.8821E-03	-51.5
10	5.5583E-01	-7.6695E-01	9.4718E-01	-54.1	-2.4564E-03	-2.5360E-03	3.5306E-03	-134.1	-1.3430E-03	-1.1290E-02	1.1369E-02	-96.8
11	9.4022E-01	-8.1437E-02	9.4374E-01	-5.0	-4.3357E-04	1.6209E-05	4.3387E-04	177.9	6.9955E-03	5.0820E-04	7.0139E-03	4.2
12	9.0198E-01	-2.7806E-01	9.4387E-01	-17.1	-3.0156E-04	1.1571E-04	3.2300E-04	159.0	7.1271E-03	2.3243E-04	7.1309E-03	1.9
13	8.2616E-01	-4.5618E-01	9.4373E-01	-28.9	5.1338E-04	1.7133E-03	1.7886E-03	73.3	7.0907E-03	-5.1546E-06	7.0907E-03	-0.0
14	7.1299E-01	-6.1630E-01	9.4243E-01	-40.8	2.3048E-03	4.9221E-03	5.4350E-03	64.9	2.9797E-03	-8.2245E-03	8.7476E-03	-70.1
15	9.4280E-01	-6.7300E-02	9.4520E-01	-4.1	-3.9207E-04	-1.3951E-03	1.4492E-03	-105.7	6.9475E-03	1.1650E-04	6.9485E-03	1.0
16	9.0631E-01	-2.6583E-01	9.4449E-01	-16.3	-8.1816E-04	-3.1399E-03	3.2447E-03	-104.6	7.3502E-03	-6.7882E-04	7.3815E-03	-5.3
17	8.3239E-01	-4.4682E-01	9.4473E-01	-28.2	-1.6015E-03	-6.5044E-03	6.6987E-03	-103.8	9.0639E-03	3.0907E-03	9.5764E-03	18.8
18	7.3517E-01	-5.8377E-01	9.3876E-01	-38.5	-3.7969E-03	-8.4624E-03	9.2751E-03	-114.2	7.1458E-04	-1.0130E-02	1.0155E-02	-86.0
19	9.4899E-01	-5.9689E-02	9.5087E-01	-3.6	1.2866E-03	-8.5686E-03	8.6646E-03	-81.5	5.8484E-03	-9.6288E-04	5.9271E-03	-9.3
20	9.0937E-01	-2.6613E-01	9.4751E-01	-16.3	-1.0428E-03	-1.0310E-02	1.0362E-02	-95.8	5.0552E-03	-3.6925E-03	6.2602E-03	-36.1
21	9.3805E-01	-9.4829E-02	9.4283E-01	-5.8	-2.3242E-04	1.2039E-04	2.6175E-04	152.6	1.9876E-02	6.0809E-04	1.9885E-02	1.8
22	8.9727E-01	-2.9277E-01	9.4383E-01	-18.1	-4.5688E-05	4.7229E-04	4.7450E-04	95.5	1.9484E-02	-2.2707E-03	1.9616E-02	-6.6
23	8.1765E-01	-4.7392E-01	9.4507E-01	-30.1	2.6302E-04	1.0328E-03	1.0657E-03	75.7	1.9096E-02	-5.3415E-03	1.9829E-02	-15.6
24	7.0710E-01	-6.2710E-01	9.4512E-01	-41.6	-1.6650E-04	1.5044E-04	2.2440E-04	137.9	2.1630E-02	-4.2342E-03	2.2040E-02	-11.1
25	5.8921E-01	-7.3276E-01	9.4027E-01	-51.2	-2.6942E-03	-2.4528E-03	3.6435E-03	-137.7	-2.0066E-03	-3.1641E-02	3.1704E-02	-93.6
26	9.3893E-01	-8.9935E-02	9.4323E-01	-5.5	-6.7648E-04	1.5580E-04	6.9419E-04	167.0	2.0132E-02	1.0456E-03	2.0159E-02	3.0
27	8.9883E-01	-2.8740E-01	9.4366E-01	-17.7	-1.9015E-04	1.4029E-03	1.4158E-03	97.7	1.9975E-02	-1.0505E-03	2.0003E-02	-3.0
28	8.2073E-01	-4.6711E-01	9.4434E-01	-29.6	1.1250E-03	3.9436E-03	4.1010E-03	74.1	1.9707E-02	-3.8581E-03	2.0081E-02	-11.1
29	7.1192E-01	-6.2051E-01	9.4439E-01	-41.1	8.2496E-04	2.8295E-03	2.9473E-03	73.7	1.7734E-02	-1.0671E-02	2.0697E-02	-31.0
30	5.8375E-01	-7.3793E-01	9.4090E-01	-51.7	-1.2353E-02	-1.3569E-02	1.8350E-02	-132.3	-6.3729E-03	-3.6153E-02	3.6711E-02	-100.0
31	9.4061E-01	-8.1014E-02	9.4409E-01	-4.9	-1.2598E-03	9.7884E-05	1.2636E-03	175.6	2.0513E-02	1.8265E-03	2.0595E-02	5.1
32	9.0198E-01	-2.7666E-01	9.4345E-01	-17.1	-6.8859E-04	1.6956E-03	1.8301E-03	112.1	2.1087E-02	1.7181E-03	2.1157E-02	4.7
33	8.2710E-01	-4.5337E-01	9.4321E-01	-28.7	8.6245E-04	5.2962E-03	5.3660E-03	80.8	2.1976E-02	-3.4778E-04	2.1978E-02	-0.9
34	7.2410E-01	-6.0104E-01	9.4104E-01	-39.7	-3.6042E-03	-4.1494E-03	5.4962E-03	-131.0	7.0576E-03	-2.6813E-02	2.7726E-02	-75.3
35	9.4133E-01	-6.3822E-02	9.4349E-01	-3.9	-3.0110E-03	4.9889E-03	5.8271E-03	121.1	2.1140E-02	1.1562E-03	2.1172E-02	3.1
36	9.0655E-01	-2.5853E-01	9.4269E-01	-15.9	-2.6570E-03	-2.2504E-03	3.4819E-03	-139.7	2.2363E-02	8.6381E-04	2.2379E-02	2.2
37	8.3521E-01	-4.2771E-01	9.3836E-01	-27.1	-7.3974E-03	-2.1052E-02	2.2314E-02	-109.4	1.8101E-02	-9.8042E-03	2.0586E-02	-28.4
38	9.4227E-01	-1.5455E-02	9.4240E-01	-0.9	3.2610E-03	-2.7208E-02	2.7403E-02	-83.2	2.0008E-02	-2.6681E-03	2.0186E-02	-7.6
39	9.1143E-01	-2.2611E-01	9.3906E-01	-13.9	-3.9766E-03	-3.3664E-02	3.3899E-02	-96.7	1.5367E-02	-1.8644E-02	2.4161E-02	-50.5
40	9.3901E-01	-9.1408E-02	9.4345E-01	-5.6	-4.3828E-04	1.4920E-05	4.3854E-04	178.1	3.2114E-02	9.0944E-04	3.2126E-02	1.6
41	8.9845E-01	-2.8927E-01	9.4387E-01	-17.8	-2.9757E-04	1.3065E-04	3.2499E-04	156.3	3.1439E-02	-3.6196E-03	3.1646E-02	-6.6
42	8.1998E-01	-4.7205E-01	9.4615E-01	-29.9	6.8083E-04	1.7707E-03	1.8971E-03	69.0	2.8371E-02	-1.2205E-02	3.0885E-02	-23.3
43	6.9060E-01	-6.5098E-01	9.4905E-01	-43.3	2.6060E-03	4.7091E-03	5.3821E-03	61.0	2.4106E-02	-2.4014E-02	3.4026E-02	-44.9
44	9.3948E-01	-8.6285E-02	9.4343E-01	-5.2	-1.2696E-03	1.1134E-04	1.2745E-03	175.0	3.2281E-02	1.1611E-03	3.2302E-02	2.1
45	8.9912E-01	-2.8566E-01	9.4341E-01	-17.6	-5.9891E-04	1.7560E-03	1.8553E-03	108.8	3.2211E-02	-2.0516E-03	3.2276E-02	-3.6
46	8.2193E-01	-4.6733E-01	9.4550E-01	-29.6	1.2137E-03	5.3927E-03	5.5276E-03	77.3	3.1597E-02	-8.3237E-03	3.2675E-02	-14.8
47	7.0817E-01	-6.2826E-01	9.4669E-01	-41.6	-3.4390E-03	-4.5708E-03	5.7200E-03	-127.0	1.7638E-02	-3.3205E-02	3.7598E-02	-62.0
48	9.4307E-01	-7.7758E-02	9.4627E-01	-4.7	-1.3875E-03	-4.2866E-03	4.5056E-03	-107.9	3.2328E-02	3.2070E-03	3.2487E-02	5.7
49	9.0317E-01	-2.7628E-01	9.4448E-01	-17.0	-1.4168E-03	5.7204E-04	1.5279E-03	158.0	3.3542E-02	1.9988E-03	3.3602E-02	3.4
50	8.2684E-01	-4.5469E-01	9.4362E-01	-28.8	-5.3876E-03	-1.0641E-02	1.1927E-02	-116.9	2.7213E-02	-1.8609E-02	3.2967E-02	-34.4
51	9.4959E-01	-9.0704E-02	9.5391E-01	-5.5	1.4814E-05	-1.3162E-02	1.3162E-02	-89.9	3.1260E-02	7.0195E-03	3.2039E-02	12.7
52	9.0778E-01	-2.6616E-01	9.4600E-01	-16.3	-4.6917E-03	-2.3421E-02	2.3886E-02	-101.3	2.9096E-02	-7.0998E-03	2.9950E-02	-13.7
53	9.4051E-01	-8.5386E-02	9.4438E-01	-5.2	-5.3210E-04	-1.4598E-03	1.5537E-03	-110.0	4.3087E-02	-4.0714E-05	4.3087E-02	-0.1
54	9.0008E-01	-2.8519E-01	9.4418E-01	-17.6	-1.1118E-03	-3.2338E-03	3.4196E-03	-109.0	4.4527E-02	4.4899E-04	4.4529E-02	0.6
55	8.3531E-01	-4.3770E-01	9.4304E-01	-27.7	-2.3127E-03	-6.1548E-03	6.5750E-03	-110.6	3.4193E-02	-2.3809E-02	4.1666E-02	-34.8
56	7.0482E-01	-6.3644E-01	9.4964E-01	-42.1	-3.9374E-03	-8.3820E-03	9.2607E-03	-115.2	3.7375E-03	-7.2334E-02	7.2431E-02	-87.0
57	9.4033E-01	-8.2649E-02	9.4396E-01	-5.0	-2.6800E-03	5.1282E-03	5.7863E-03	117.6	4.2979E-02	-1.6017E-03	4.3009E-02	-2.1
58	8.9969E-01	-2.8915E-01	9.4502E-01	-17.8	-2.4713E-03	-2.1591E-03	3.2817E-03	-138.9	4.3184E-02	-6.5874E-03	4.3684E-02	-8.7
59	8.2150E-01	-4.7018E-01	9.4654E-01	-29.8	-8.3148E-03	-2.0817E-02	2.2416E-02	-111.8	3.1870E-02	-3.2291E-02	4.5370E-02	-45.4
60	9.4092E-01	-4.0869E-02	9.4181E-01	-2.5	-2.4513E-03	-1.3360E-02	1.3583E-02	-100.4	4.3751E-02	-4.6802E-03	4.4001E-02	-6.1
61	9.0177E-01	-2.7963E-01	9.4413E-01	-17.2	-4.8116E-03	-2.2995E-02	2.3493E-02	-101.8	3.8774E-02	-2.4817E-02	4.6036E-02	-32.6
62	9.4257E-01	-7.0379E-02	9.4520E-01	-4.3	5.0711E-03	-6.5218E-02	6.5415E-02	-85.6	3.6532E-02	-6.1218E-03	3.7041E-02	-9.5

63	9.4231E-01	-5.5613E-02	9.4395E-01	-3.4	-1.6450E-04	-9.0539E-03	9.0554E-03	-91.0	5.2800E-02	-7.0177E-03	5.3265E-02	-7.6
64	9.0053E-01	-2.9047E-01	9.4622E-01	-17.9	-2.1107E-03	-1.0574E-02	1.0783E-02	-101.3	4.7261E-02	-3.0961E-02	5.6500E-02	-33.2
65	9.4744E-01	-8.6280E-02	9.5136E-01	-5.2	1.4714E-03	-2.8031E-02	2.8069E-02	-87.0	4.9338E-02	-8.9762E-03	5.0147E-02	-10.3
66	9.0011E-01	-3.1359E-01	9.5317E-01	-19.2	-4.9223E-03	-3.4427E-02	3.4777E-02	-98.1	4.2104E-02	-3.6673E-02	5.5836E-02	-41.1

TOTAL POWER IN THE BODY = 3.73706E-06 WATTS

HBR16TG2 -- JOB 3876 -- HASP-II OUTPUT COMPLETE AT 11:41